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November 18, 2021

VIA ELECTRONIC FILING

The Honorable Jocelyn G. Boyd
Chief Clerk and Executive Director
Public Service Commission of South Carolina
101 Executive Center Drive, Suite 100
Columbia SC 29210

**Re: Petition of Duke Energy Carolinas, LLC and Duke Energy Progress, LLC for Approval of CPRE Queue Number Proposal, Limited Waiver of Generator Interconnection Procedures, and Request for Expedited Review
Docket No. 2018-202-E**

Update on Most Recent DER TSRG Meeting

Dear Ms. Boyd:

Pursuant to the Public Service Commission of South Carolina's ("Commission") Order No. 2019-247 issued on April 9, 2019, in the above-captioned docket, Duke Energy Carolinas, LLC and Duke Energy Progress, LLC (collectively, the "Companies") hereby respectfully provide the Commission an update on the Companies' most recent Distributed Energy Resources ("DER") Technical Standards Review Group ("TSRG") meeting held on October 20, 2021.

The following attachments enclosed with this update provide a more detailed account of the previous TSRG meeting and issues discussed:

- **Attachment A:** October 20, 2021 Meeting Agenda
- **Attachment B:** October 20, 2021 Minutes and Attendance
- **Attachment C:** Update and Discussion-Action Plan to Implement 1547-2018
- **Attachment D:** Implementation of IEEE 1547-2018 Guidelines (Redline)
- **Attachment E:** Implementation of IEEE 1547-2018 Guidelines (Clean)
- **Attachment F:** DER Commissioning Update
- **Attachment G:** Substation Configuration Guideline for Transmission IBR Interconnections
- **Attachment H:** TSRG Operations Update

- **Attachment I:** General Discussion and Updates
- **Attachment J:** Organizational Chart – Renewable Integration

As described in the Companies' June 6, 2019 Report in this docket, the TSRG webpage, <https://www.duke-energy.com/business/products/renewables/generate-your-own/tsrg>, provides meeting materials from each prior TSRG meeting, as well as other technical standards documents. The next TSRG meeting is tentatively scheduled for January 19, 2022.

Kind regards,

A handwritten signature in blue ink, appearing to read 'Sam Wellborn', with a stylized flourish at the end.

Sam Wellborn

Attachments

cc: Parties of Record (via email with attachments)

Technical Standards Review Group (TSRG)
Duke Energy Carolinas/Progress
Meeting Agenda
October 20, 2021

In-person meeting converted to web meeting to follow distancing guidelines for COVID-19

- | | |
|-------|--|
| 9:00 | Meeting Administrator remarks |
| 9:02 | Safety & Welcome – Wes Davis, Duke |
| 9:05 | IEEE 1547 implementation update – Anthony Williams, Duke |
| 9:40 | Inspection and commissioning update – Kevin Chen, Duke |
| 10:30 | BREAK |
| 10:45 | Operations update – Darren Maness, Duke |
| 11:15 | General Discussion and Updates <ul style="list-style-type: none"> • Enterprise Protection Update – Philip Baker, Duke • Enterprise Substation Configuration – Kristina Straple, Duke • Standalone storage discussion – <div style="margin-left: 40px;">Mike Wallace, BrightNight / Ken Jennings, Duke</div> <ul style="list-style-type: none"> ○ Stakeholders to introduce discussion topics of interest • Guidance map update <ul style="list-style-type: none"> ○ DG Guidance map publication postponed from October 2021 to January 2022. ○ Projects currently in the interconnection queue have a 10/31 deadline to make a decision on whether they will withdraw or participate in the first (transitional) cluster study. As a result, substantial changes to the queue are expected in early November and would make an October update immediately obsolete. |
| 11:55 | Wrap up & next meeting date – Wes Davis, Duke
(Recommend January 19) |
| 12:00 | ADJOURN |

Duke Energy Carolinas/Progress Interconnection Technical Standards Review Group (TSRG)

Meeting Minutes

October 20, 2021

I. Opening

This is a regular meeting called to order at 9:05 AM. The meeting was conducted by web conference.

Meeting facilitator: Anthony Williams

Minutes: Anthony Williams

II. Record of Attendance

Member Attendance

Name	Affiliation	Attendance
Kevin Chen	Duke Energy	present
Wes Davis	Duke Energy	present
Ken Jennings	Duke Energy	present
Huimin Li	Duke Energy	present
Darren Maness	Duke Energy	present
Orvane Piper	Duke Energy	present
Bill Quaintance	Duke Energy	present
Scott Reynolds	Duke Energy	absent
Anthony Williams	Duke Energy	present
Stephen Barkaszi	Duke Energy	absent
Ben Brigman	Ecoplexus	present
Paul Brucke	Brucke Engineering	present
David Brueck	Southern Current	absent
Matt Delafield	R-E Services	absent
Jason Epstein	Southern Current	absent
Adam Foodman	O2 Energies EMC	present
Bruce Fowler	BAM Energy	absent
Sean Grier	Duke Energy	absent
Scott Griffith	Duke Energy	present
John Gajda	Strata Solar	present
Chuck Ladd	Ecoplexus	absent
Bruce Magruder	BAM Energy	absent
Brad Micallef	Solar Operations Solutions	present
Luke O'Dea	Cypress	absent
Luke Rogers	Birdseye Renewable Energy	absent
Chris Sandifer	SCSBA	present
Mike Whitson	PowerOn Energy	present
John Wilson	Southern Current	absent
James Wolf	Yes Solar Solutions	absent
Jay Lucas	NC Public Staff	absent
James McLawhorn	NC Public Staff	absent
Dustin Metz	NC Public Staff	present

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Name	Affiliation	Attendance
Tommy Williamson	NC Public Staff	present
Dawn Hipp	SC Office of Regulatory Staff	absent
Sarah Johnson	SC Office of Regulatory Staff	absent
Robert Lawyer	SC Office of Regulatory Staff	absent
Morgan O'Neil	SC Office of Regulatory Staff	present

Guest Attendance

Name	Affiliation	Attendance
Terri Edwards	Duke Energy	present
Kristina Straple	Duke Energy	present
Philip Baker	Duke Energy	present
Kelsy Green	Advanced Energy for Duke Energy	absent
Staci Haggis	Advanced Energy for Duke Energy	present

III. Current agenda items and discussion

- 1) The agenda was emailed prior to the meeting.
- 2) Wes Davis provided the welcome and safety message

- 3) PRESENTATION: IEEE 1547 implementation update – Anthony Williams, Duke
 - A) Presentation will be provided with the meeting minutes
 - B) Industry question – Why are some IEEE sections are missing from the Guidelines?
 - (i) Duke response – Lower priority sections of 1547 are not in the Guidelines. The priority of addressing the Standard sections was determined early in the formation of the scope of the effort. The TSRG conducted a poll to select and prioritize the 1547 topics. The highest priority items are listed in order in the table in the Introduction section of the Guidelines (titled Duke Energy Selected Order of Precedence for IEEE 1547 Sections). Sections that are not included are lower priority by default. That could be because the items are of less interest to TSRG members or that there is a well understood practice addressing that Standard requirement.

- 4) PRESENTATION: Inspection and commissioning update – Kevin Chen, Duke
 - A) Presentation will be provided with the meeting minutes
 - B) Industry question – Will Duke charge the customer for the time spent in the MOA negotiation process?

Duke Energy Carolinas/Progress Interconnection Technical Standards Review Group (TSRG)**Meeting Minutes****October 20, 2021**

- (i) Duke response – No, Duke wants to minimize the effort spent on this since a MOA is already developed. To be most efficient, Duke prefers others also use the MOA or use the AE (Advanced Energy) process that is in place now.
- C) Industry question – Can Duke share the details of Duke-Strata MOA and corresponding documents developed under the MOA for other interconnection customer to review and consider using as template for their MOA with Duke?
 - (i) Duke response – Duke will post the MOA and the additional Duke-related documents.
 - (ii) ACTION ITEM – Duke will post the MOA and the additional Duke-related documents soon.
- 5) PRESENTATION: Operations update – Darren Maness, Duke
 - A) Presentation will be provided with the meeting minutes
 - B) Industry question – Is there a follow-up mechanism on the replacement process? What should the customer be doing?
 - (i) Duke response – Renewable Integration has restructured. The new organization is aligned with the DER life cycle from commissioning to end of life. As always, a customer can still contact their account manager. Additionally, operational issues are under Wes Davis DER Technical Standards, so customers can contact Wes and Darren now too.
 - C) Discussion – Stakeholders commented that it would be good to see new organizational structure.
 - (i) ACTION ITEM – Duke will share the new roles and responsibilities.
 - (a) This item was completed and provided with the minutes.
 - D) Industry question – How is the coordination handled between Duke and the customer if the meter is bypassed? How will the customer receive communications after the I&C tech has completed the bypass activity?
 - (i) Duke response – That portion of the process is unchanged. Follow the same process as today. Also, operations issues and communication can go through Darren or DEROperations@duke-energy.com.
 - E) Industry question – Stakeholders asked about the process to follow up on recloser operations to determine the cause of nuisance tripping.
 - (i) Duke response – Follow the normal process for initiating a Duke review or crew dispatch. Duke also noted that after review of events at several sites, it is common for site conditions or site equipment opening and causing outages in addition to events on the system causing the utility recloser to open.
- 6) General Discussion and Updates
 - A) Enterprise Protection Update – Philip Baker, Duke
 - (i) Presentation will be provided with the meeting minutes

Duke Energy Carolinas/Progress Interconnection Technical Standards Review Group (TSRG)**Meeting Minutes****October 20, 2021**

- (ii) Discussion –Customers can experience tripping of Duke’s recloser in low or no current conditions. Will Duke’s protection setting update resolve this issue?
 - (a) Duke response – These settings are not specifically part of this project. It could be that the updated settings could make the recloser more discriminating in the future.
 - B) Enterprise Substation Configuration – Kristina Straple, Duke
 - (i) Presentation will be provided with the meeting minutes
 - (ii) There was no discussion.
 - C) Standalone storage discussion – Mike Wallace, BrightNight / Ken Jennings, Duke
 - (i) Discussion – Mike was unable to attend this portion of the meeting. Ken gave a brief update on standalone storage interconnection requests.
 - (ii) Industry question – Is there a special interconnection process for these sites or is it the traditional process?
 - (a) Duke response – Duke continues to use the same study process. The main difference is including the charging mode in addition to generation. DC charging would be studied following the retrofit process/procedure. Maura Farver is leading this policy effort.
 - D) Guidance map update
 - (i) Duke provided the following update
 - (a) DG Guidance map publication postponed from October 2021 to January 2022.
 - (b) Projects currently in the interconnection queue have a 10/31 deadline to make a decision on whether they will withdraw or participate in the first (transitional) cluster study. As a result, substantial changes to the queue are expected in early November and would make an October update immediately obsolete.
 - E) Unit cost comparisons –Ken Jennings, Duke
 - (i) This topic was added during the meeting
 - (ii) Discussion – Duke reiterated that the plan is to form a task force to address unit cost comparisons. Normally we update the estimates prior to tranche 3 estimates This would refresh the issue with all the duke experts and duke could discuss frequency of update going forward. We would look for a small group of industry participants to address this.
- 7) Wrap up & next meeting date – Anthony Williams, Duke
- A) Next meeting planned to be a web conference.
 - (i) Recommended January 19, 2022

IV. Closing

This meeting concluded at 11:31 AM

Duke Energy Carolinas/Progress Interconnection Technical Standards Review Group (TSRG)**Meeting Minutes****October 20, 2021****V. Attachments**

- 1) Agenda, "TSRG Agenda 2021_1020, Rev 0.pdf"
- 2) Presentations
 - A) IEEE 1547 implementation update, "TSRG Implement 1547 Update, Oct 20 2021, Rev 0.pdf"
 - B) Inspection and commissioning update, "DER commissioning_TSRG_10202021.pdf"
 - C) Operations update, "TSRG Operations Update 10-20-21.pdf"
 - D) General Discussion and Updates, "General Discussion and Updates.pdf"
 - E) Guideline for Transmission IBR Interconnections, "SubConfigGuideline_TSRG meeting r1.pdf"
- 3) References
 - A) 1547 Guidelines with edits, "Duke Energy IEEE 1547 Implementation Guidelines, Rev 5C.pdf"
 - B) 1547 Guidelines latest version, "Duke Energy IEEE 1547 Implementation Guidelines, Rev 6.pdf"
 - C) Renewable Integration roles and responsibilities, "Renewable Integration Organization.pdf"

Update and Discussion: Action Plan to Implement 1547-2018 TSRG Meeting

Anthony C Williams, P.E.
Principal Engineer

DER Technical Standards
July 21, 2021



- Review main revisions
 - Current version is “Duke Energy IEEE 1547 Implementation Guidelines, Rev 6”
 - Rev 5C is the red marked version
- Discussion

- As sections are in progress, there is a sentence at the end that summarizes the open items, example:
 - “Implementation of this section requires applying the interoperability functionality in the local interface and integrating verification requirements into the overall commissioning test program.”
 - Interoperability and verification are open items
- In the future, once these items are completed, there will be no summary phrase.
 - Use of the phrase below will be discontinued: “This section is ready to be implemented.”

- SECTION 4.6 – CONTROL CAPABILITY REQUIREMENTS
 - MW breakpoints for recloser and automation controllers
- SECTION 7.2.2 – RAPID VOLTAGE CHANGES
 - Copied in the text for current practice
- SECTION 7.2.3 – FLICKER
 - Noted power quality meter is the current requirement

- Focusing on identification of those sections that could be ready in Phase 1 of an implementation plan
 - As noted last time, evaluating topics to align with others in industry
- This effort has created a few changes
 - SECTION 7.3 – LIMITATION OF CURRENT DISTORTION
- Division of Interoperability requirements
 - SECTION 10.1, 10.7, 10.8, 10.9 – GENERAL INTEROPERABILITY AND PROTOCOL REQUIREMENTS
 - Focus on general requirements
 - Mainly the hardware and protocol requirements
 - SECTION 10.2, 10.3, 10.4, 10.5, 10.6 – DATA, MONITORING, AND CONTROL
 - Sections 10.3 and 10.4 primarily contain nameplate and configuration information
 - Sections 10.5 and 10.6 provide real-time monitoring, control, and status information that is dependent upon the specific functions in use; therefore spread throughout the Guidelines by topic.

- Written feedback and comments will be solicited using comment form
 - Note questions then lets discuss – don't really want all the questions sent in that are mainly just for clarification – this takes a lot of time to address that could be spent on the comments and recommendations
 - It would be helpful to provide both comments and also propose a specific change:

Stakeholder Name	Page Number	Paragraph Number	Comment	Proposed Change
example Question format	3	2	Why is winter data excluded?	None
example Comment format	7	4	Agree with the hours of study.	None
example Comment format	7	4	'the largest' is not clear	Replace 'the largest' with 'the maximum of the three phase currents'
example Recommendation format	10	3	The types of faults is too limited. Include single line to ground faults.	Include SLG faults

- Suggesting the exact change to the Guidelines reinforces the main point of the comment and provides more information that Duke can specifically address
- Comments will be taken during the meeting and the form will be distributed after the meeting
- Stakeholders may provide written feedback using the feedback form

ATTACHMENT C



Implementation of IEEE 1547-2018 Guidelines for Duke Energy Carolinas and Duke Energy Progress

Duke Energy

Duke Energy Carolinas and Duke Energy Progress

Distributed Energy Technology

DER Technical Standards

Revision 5C

July 20, 2021



**Implementation of IEEE 1547-2018 Guidelines for
Duke Energy Carolinas and Duke Energy Progress**

Revision	Date	Description
0	3/31/2020	Initial issue
1	7/21/2020	General update prior to Jul. 2020 TSRG meeting
2	10/28/2020	General update prior to Oct. 2020 TSRG meeting
3	1/20/2021	General update prior to Jan. 2021 TSRG meeting
4	4/28/2021	General update prior to Apr. 2021 TSRG meeting
5	7/20/2021	General update prior to Jul. 2021 TSRG meeting
5C	10/19/2021	Red marked version of Rev5

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INTRODUCTION

Duke Energy seeks to implement smart inverter technical specifications and requirements as defined in the updated IEEE Standard 1547-2018, IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems (IEEE 1547 or the Standard). This document focuses only on the distributed energy resources (DER) connected to the distribution system and not those connected to the transmission or bulk power system (BPS). In North and South Carolina, the implementation of IEEE 1547 is focused on large utility scale DER (UDER) because there had been significant number of those installations. Some of IEEE 1547 requirements are also applicable to the smaller retail and residential DER (RDER). If there are any variations in application of the Standard to UDER and RDER, those conditions will be noted in this document.

Note to the format of this document. This guideline is meant to be a living document. For now, it captures where Duke Energy is in the process of implementing IEEE 1547-2018. This document notes sections of the standard that require no additional analysis or review and those that are under review and those that must still be reviewed. In sections highlighted like this paragraph, there will be a brief discussion of the ongoing work to be concluded to address implementation of that Standard section.

The standard is an inverter Standard and not a utility standard, therefore many parts of the Standard can be implemented by Duke Energy simply by adopting IEEE 1547-2018 as the applicable standard for Duke Energy inverter based interconnections. However, there are some sections of the Standard that require input or specifications from the utility. The Standard specifies inverter capabilities and functions, but not utilization. The purpose of this document is to clarify any additional information for utilization.

The standard is applicable to DER connected at the primary or secondary distribution system voltage levels. However, some of the Standard requirements are based on conditions and issues related to the BES. There can be situations where the aggregate distribution DER capacities are large enough to impact the NERC BES reliability. In those cases, BES requirements are implemented in DER connected to the distribution system. However, these requirements are not directly distribution requirements, but BES requirements applied at the distribution power system level. The interaction between the BES and the distribution system is well covered in the [NERC Reliability Guideline](#): Bulk Power System Reliability Perspectives on the Adoption of IEEE 1547-2018. The guideline recommends that the BPS entities (BA, RC, PC, TP) coordinate with the Distribution Providers (DP) to achieve successful implementation of the Standard.

This Duke Energy Guideline is applicable to DER located in the Duke Energy service territories in North Carolina and South Carolina. The Guidelines have been developed based on input and comments from TSRG stakeholders.

CONSIDERATION OF IEEE 1547 SECTIONS THAT COULD INCREASE INTERCONNECTION CAPABILITY

The following IEEE 1547 controls or functions are the primary functions that could potentially increase the amount of DER capacity (higher penetration) that can interconnect with minimal feeder upgrades:

- i) 4.6.2 Capability to limit active power
- ii) 5.3 Voltage and reactive power control
- iii) 5.4 Voltage and active power control

While power quality issues can still restrict interconnection, the voltage and reactive power controls are a potential mitigation to those issues too.

While there are other inverter functions that improve reliability of the interconnection, the inverter functions listed above would be the primary drivers for adding more DER capacity to a feeder. Therefore, these functions were assigned a higher priority to review and analyze.

CONSIDERATION OF IEEE 1547 SECTIONS THAT IMPACT GRID SUPPORT

In addition to prioritizing assessment of those sections of IEEE-1547 that could increase interconnection capability, the Companies are also prioritizing those sections that could impact grid support. The 2003 version of the standard created reliability concerns by not providing voltage regulating capability and tripping for abnormal system conditions. While the 2014 version addressed some of the grid reliability concerns, 2018 provides even more inverter capabilities. Also, documents such as the NERC Reliability Guideline: Bulk Power System Reliability Perspectives on the Adoption of IEEE 1547-2018 focus “on ensuring reliable operation of the BPS under increasing penetrations of BPS-connected inverter-based resources as well as distributed energy resources (DERs).” One objective of such documents is to encourage timely adoption of the IEEE 1547-2018 that are likely to impact or support the BPS.

The priority of review of the Standard sections identified in the table is consistent with this industry guidance in that many of the first and second priority selected topics were noted in the NERC guideline as well. Sections 4.2 and 4.10.2 are fourth priority for Duke, but that is mainly because these topics are thought to be more straightforward to address and will likely not require significant evaluation. Interoperability was noted by NERC and Duke plans to address that on a topic by topic basis rather than as one stand-alone interoperability topic. In this way, interoperability is addressed concurrent with the technical considerations for each topic.

The following topics are yet unranked by Duke, but they are in the NERC guideline: 6.4.2.7, 6.5.2.8, 8.1, 8.2. Section 6.4.2.7 was added to the Duke list after the NERC guideline review. These were not ranked during the Duke process because of the lower priority placed on them by the TSRG stakeholders and Duke. These are also topics that need more time and investigation by the industry, so addressing some of the better understood and higher prioritized items first is a reasonable path forward.

PRIORITY OF IMPLEMENTING THE IEEE 1547 TECHNICAL SPECIFICATIONS AND REQUIREMENTS

There are many aspects of implementing the Standard that must be considered. The technical specifications and requirements must be understood and assessed to determine if there is a need to clarify any technical points for consistent application across the Duke system. Duke subject matter experts, TSRG stakeholders, NC Public Staff, and industry documents were included in the activity to set priority for the various Standard sections. The areas of the Standard that stand out as most important are the ride through capability and voltage and reactive power controls.

Below is the priority order at this time considering all TSRG input. If there is no priority stated in the list, then the priority of those items is yet to be assigned. Note that the priority group and the assigned Duke identification number¹ for that item are both in the first column. The remaining IEEE 1547-2018 clauses and sections that do not have a priority assigned will be undertaken following the completion of the higher priority topics. The three columns on the far right side of the table summarize the status for the technical, interoperability, and verification and test aspects for each Standard topic. Many of the summaries are not the final decision because the topic requires more analysis and assessment. However, this table still provides a general overview.

¹ Only the prioritized Duke identification numbers represent the sequence of evaluation, and are numbered less than 100. Numbers greater than 100 are temporarily assigned to the topic until that topic is given a specific priority.

1

2 Duke Energy Selected Order of Precedence for IEEE 1547 Sections

TSRG Priority Order (Duke ID)	IEEE 1547 Section	IEEE 1547-2018 Topic	Technical Position Summary	Interoperability Summary	Test and Verification Summary
1 (DUK-01)	5.2	Reactive power capability of the DER	Category B	No Reqmt	Eval + Comm Test
1 (DUK-02)	5.3	Voltage and reactive power control	Study in progress, constant pf initially	Yes	Eval + Comm Test
1 (DUK-03)	5.4.2	Voltage-active power control	Study in progress, not used initially	Yes	Eval + Comm Test
1 (DUK-04)	7.4	Limitation of overvoltage contribution	Accept 1547 with additional requirements	No Reqmt	Eval + Comm Test
1 (DUK-05)	7.2.3	Power Quality, Flicker	Accept 1547 in conjunction with continued use of IEEE 1453	No Reqmt	Eval + Comm Test
1 (DUK-06)	7.2.2	Power Quality, Rapid voltage change (RVC)	Continue existing criteria and policy	No Reqmt	TBD , Eval + Comm Test
2 (DUK-07)	6.4.1	Mandatory voltage tripping requirements (OV/UV)	Have existing setpoints; new 1547 setpoint study in progress	TBD	Eval + Comm Test
2 (DUK-08)	6.5.1	Mandatory frequency tripping requirements (OF/UF)	Have existing setpoints; new 1547 setpoint study in progress	TBD	Eval + Comm Test
2 (DUK-09)	6.4.2	Voltage disturbance ride-through requirements	Study in progress	TBD	Eval + Comm Test
2 (DUK-10)	6.5.2	Frequency disturbance ride-through requirements	Study in progress	TBD	TBD, Eval + Comm Test
2 (DUK-11)	6.5.2.7	Frequency-droop (frequency-power) capability	Evaluation has not begun	No Reqmt	TBD, Eval + Comm Test
2 (DUK-12)	6.5.2.6	Voltage phase angle changes ride-through	Study in progress	No Reqmt	TBD, Eval + Comm Test
2 (DUK-103)	8.1	Unintentional islanding	TBD	Yes	TBD, Eval + Comm Test
3 (DUK-13)	4.5	Cease to energize performance requirement	Accept 1547 as written	No Reqmt	Eval + Comm Test

TSRG Priority Order (Duke ID)	IEEE 1547 Section	IEEE 1547-2018 Topic	Technical Position Summary	Interoperability Summary	Test and Verification Summary
3 (DUK-14)	4.6.1	Capability to disable permit service	Accept 1547, with notes-as-written	Yes	Eval + Comm Test
3 (DUK-15)	4.6.2	Capability to limit active power	Accept 1547, static limits-as-written	Yes	Eval + Comm Test
4 (DUK-16)	6.5.2.5	Rate of change of frequency (ROCOF)	Study in progress	TBD	Eval + Comm Test
4 (DUK-17)	4.2	Reference points of applicability (RPA)	Accept 1547 as written ; consider clarifications	No Reqmt	TBD , Eval.
4 (DUK-18)	4.3	Applicable voltages	Accept 1547 as written ; consider clarifications	Yes	TBD , Eval.
4 (DUK-19)	4.10.2	Enter service criteria // 6.6 Return to service after trip	Accept 1547 as written ; consider clarifications	No Reqmt	TBD, Eval + Comm Test
4 (DUK-20)	4.10.3	Performance during entering service	Accept 1547 as written ; consider clarifications	No Reqmt	Eval + Comm Test
4 (DUK-21)	4.10.4	Synchronization	Accept 1547 as written ; consider clarifications	No Reqmt	TBD, Eval + Comm Test
4 (DUK-22)	4.11.3	Paralleling device	Accept 1547 as written	No Reqmt	Type Test
5 (DUK-23)	4.9	Inadvertent energization of the Area EPS	Accept 1547 as written	No Reqmt	Eval + Comm Test
5 (DUK-24)	6.3	Area EPS reclosing coordination	Accept 1547 as written ; consider clarifications; part of ongoing study	No Reqmt	Eval.
5 (DUK-25)	6.2	Area EPS faults and open phase conditions	Accept 1547 as written ; consider clarifications; part of ongoing study	TBD	Eval + Comm Test
5 (DUK-26)	4.12	Integration with Area EPS grounding	Accept 1547 with clarifications	No Reqmt	Eval.
5 (DUK-27)	4.7	Prioritization of DER responses	Accept 1547 as written	No Reqmt	TBD, Eval + Comm Test
5 (DUK-28)	4.8	Isolation device	Accept 1547 with notes-as-written	No Reqmt	Eval + Comm Test

TSRG Priority Order (Duke ID)	IEEE 1547 Section	IEEE 1547-2018 Topic	Technical Position Summary	Interoperability Summary	Test and Verification Summary
5 (DUK-29)	4.11.1	Protection from electromagnetic interference	Accept 1547 as written	No Reqmt	Type Test
5 (DUK-30)	4.11.2	Surge withstand performance	Accept 1547 as written	No Reqmt	Type Test
5 (DUK-31)	4.6.3	Execution of mode or parameter changes	Accept 1547 as written	TBD, Yes	TBD, Eval + Comm Test
- (DUK-101)	9	Secondary network	Duke does not currently have these	No Reqmt	-
- (DUK-102)	11.4	Fault current characterization	TBD	No Reqmt	-
- (DUK-104)	8.2	Intentional islanding	TBD	Yes	-
- (DUK-105)	11	Test and verification	TBD	-	-
- (DUK-106)	10.2	Monitoring, control, and information exchange requirements	TBD	Yes	-
- (DUK-107)	10.5	Monitoring information	TBD	Yes	-
- (DUK-108)	6.4.2.5	Ride-through of consecutive voltage disturbances	TBD	No Reqmt	-
- (DUK-109)	6.4.2.6	Dynamic voltage support	TBD	No Reqmt	-
- (DUK-110)	6.5.2.8	Inertial response	TBD	No Reqmt	-
- (DUK-111)	10.1	Interoperability requirements	TBD	Yes	-
- (DUK-112)	10.3	Nameplate Information	TBD	Yes	-
- (DUK-113)	10.4	Configuration information	TBD	Yes	-
- (DUK-114)	10.6	Management information	TBD	Yes	-
- (DUK-115)	10.7	Communication protocol requirements	TBD	Yes	-
- (DUK-116)	10.8	Communication performance requirements	TBD	Yes	-

TSRG Priority Order (Duke ID)	IEEE 1547 Section	IEEE 1547-2018 Topic	Technical Position Summary	Interoperability Summary	Test and Verification Summary
- (DUK-117)	10.9	Cyber security requirements	TBD	Yes	-
- (DUK-118)	7.3	Limitation of current distortion	Accept 1547	No Reqmt	Type Test
- (DUK-119)	4.13	Exemptions for Emergency Systems and Standby DER	TBD	TBD	-
- (DUK-120)	6.4.2.7	Restore output with voltage ride-through	TBD	No Reqmt	0

LOGISTICS OF IMPLEMENTING OF IEEE 1547-2018

After the technical aspects of each Standard section are understood, Duke Energy can then determine the necessary changes to implement that section. This could vary from taking no action, to updating documentation, to changing work, study, and operational practices. Additionally, a consequence of more inverter functions will be the necessary increase in interoperability requirements as well as DER equipment and DER system verification and testing to confirm design and functional requirements. There are many aspects to consider before implementing each 1547 section. Because the actions to implement each section can vary widely, the implementation will be addressed in each section rather than as a whole for the entire Standard.

It is understood that many of the functions will not be available until IEEE 1547-2018 certified inverters are tested and available to the market. At that time, Duke Energy shall require all inverters to be IEEE 1547-2018 certified. All functions and requirements may not be applicable or implemented at the time the inverters become certified or that Duke Energy requires the certification.

Duke Energy has no plans to implement the new functions of IEEE 1547-2018 for existing inverters. Not only is it not a common practice at Duke to retroactively apply standards, it is really not even a valid option because existing inverters do not have many of the 1547-2018 capabilities and were not tested to UL 1741 SB. If a 1547-2018 function is implemented and there is a comparable IEEE 1547a-2014 function for inverters certified to UL 1741 SA, then Duke Energy and the DER Owner may mutually agree to implement those available functions as needed. Similarly, some functions like voltage and frequency tripping have existed throughout all versions of 1547. Revising pre-existing settings is not considered implementation of a new function.

PLANT REQUIREMENTS

Guidelines must consider how all sections may apply if implemented on a plant-scale with a power plant controller rather than at the individual inverter units. There may need to be some tests for verification that

the plant controller performs the intended functions and that the underlying inverters to not behave contrary to the plant controller configuration or commands.

Note that in the following part of this document, the title of each section is the IEEE 1547-2018 section or subsection number and title.

SECTION 1.4 – GENERAL REMARKS AND LIMITATIONS

Duke accepts the requirements in the Standard.

~~Duke Energy accepts the scope of the Standard as specified in this section.~~ For UDER, the single point of common coupling (PCC) is located at the boundary between the utility electric power system (EPS) and the local EPS or DER EPS.

The technical specifications and requirements for some performance categories are specified by general technology-neutral categories. For categories related to reactive power capability and voltage regulation performance requirements, Duke Energy requires the following normal performance category:

Voltage and Reactive Power Category B

For categories related to response to Area EPS abnormal conditions, Duke Energy requires the following abnormal operating performance categories:

Synchronous generation	Category I
Induction generation	Mutual agreement
Inverter-based generation	Category III*
Inverter-based storage	Category III*

This section shall be applicable once 1547-2018 inverters are certified and required or if by mutual agreement between Duke Energy and the DER Owner for inverters certified to IEEE 1547a-2014 or UL 1741 SA.

* Final determination for the Category has not been made. More analysis is required and included as part of a study conducted jointly between the Duke Protection and Transmission Planning groups. This work includes a significant effort to model the system, perform iterative studies, and perform research. The main focus is on Category II and that is expected to be the minimum requirement for IBR. With the amendment to IEEE 1547a-2020 approved and many utilities standardizing on Category III, that is the most likely selection.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Independent laboratory certifications that attest to the normal and abnormal categories shall satisfy verification for this requirement.

Implementation of this section requires publishing the final position and integrating verification requirements into the overall commissioning test program.

SECTION 4.2 – REFERENCE POINTS OF APPLICABILITY (RPA)

Duke accepts the requirements in the Standard.

Duke Energy requires the RPA for all performance requirements for UDER to be the PCC (point of common coupling), which is also known as the point of delivery or change of ownership point on the medium voltage side of the DER transformer(s). The RPA for net meter installations is the PoC (point of connection) at the inverter terminals.

See the decision trees in the informative Annex H, in of the Standard and the decision tree in IEEE 1547.2.

~~Duke may choose to also reference Figure 3, "Use of Power Limiting in the RPA Selection Process" from the final 1547.2 Standard once the standard is published. This figure contains a flow chart that may be more concise than those in Annex H.~~

~~Pending analysis: The expectation is that Duke can accept the Standard as written, but Duke must still determine if there are any applicable exceptions or clarifications needed given this portion of section 4.2:~~

Alternatively, for Local EPSs where zero sequence continuity²⁷ between the PCC and PoC is maintained and either of the following conditions apply, the RPA for performance requirements of this standard may be the *point of DER connection* (PoC), or by mutual agreement between the *Area EPS* operator and the *DER operator*, at any point between, or including, the PoC and PCC:

- a) Aggregate DER nameplate rating of equal to or less than 500 kVA, *or*
- b) Annual average load demand²⁸ of greater than 10% of the aggregate DER nameplate rating, and where the Local EPS is not capable of, or is prevented from, exporting more than 500 kVA for longer than 30 s.

For all other Local EPSs meeting either of the conditions a) or b) above but not meeting the requirement for zero sequence continuity, the RPA for performance requirements other than the response to *Area EPS* abnormal conditions specified in 6.2 and 6.4 shall be the PoC, or by mutual agreement between the *Area EPS operator* and the *DER operator*, at any point between, or including, the PoC and PCC. The RPA for performance requirements of 6.2 and 6.4 shall be a point between, or including, the PoC and PCC that is appropriate to detect the abnormal voltage conditions.^{29, 30}

Where the RPA is not at the PCC, any equipment or devices in the Local EPS between the RPA and the PCC shall not preclude the DER from meeting the disturbance ride-through requirements specified in 6.4.2 and 6.5.2.³¹

For Local EPS where aggregate DER nameplate rating is greater than 500 kVA, and annual average load demand²⁸ is greater than 10% of the aggregate DER nameplate rating, and the Local EPS is capable of, and is not prevented from, exporting more than 500 kVA for longer than 30 s, the RPA shall be the PCC and

~~The final position must consider the variety of RDER and UDER interconnections and identify the RPA for each. In practice, the interconnections have been very straightforward. The default RPA is the PCC. Zero sequence continuity is not a factor for UDER, so the RPA for UDER is the PCC (point of common coupling at the utility interconnection point). The RPA for net meter installations must consider a variety of conditions, as noted in the decision trees, H.1 and H.2. Note that Section 4.12 also addresses grounding and zero sequence continuity.~~

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Duke will to review DER design documents to confirm the location of the RPA is correct.

~~Implementation of this section requires publishing the final technical position.~~

SECTION 4.3 – APPLICABLE VOLTAGES

~~Duke Energy will consider if there is a need to clarify any technical points for the final version of the guideline, but the expectation is that the section is implemented as written. The expected outcome is that RDER parameters shall be monitored at the inverter terminals and UDER parameters shall be monitored at the EPS voltage level and used for inverter functions.~~

Duke accepts the requirements in the Standard ~~as written~~. The Method of Service Guidelines addresses interconnection voltages.

Interoperability requirements: Applicable voltages are provided to the local DER interface with Duke Energy.

Verification and test requirements: ~~The applicable voltages will be established during the interconnection process. Duke plans to review design document to verify the DER meet this requirement. To be determined.~~

~~The applicable voltage should be identified in the interconnection process. Duke plans to review design document to verify the DER meet this requirement.~~

~~Implementation of this section requires applying the interoperability functionality in the local interface, and integrating verification requirements into the overall commissioning test program.~~

SECTION 4.5 – CEASE TO ENERGIZE PERFORMANCE REQUIREMENT

Duke Energy requires cease to energize capability (not delivering power during steady-state or transient conditions) in accordance with the Standard. ~~This can be an inbuilt function of the source or by disconnecting from the local EPS. The former is the preferred method.~~

A DER can be directed to cease to energize and trip by changing the Permit service setting to “disabled” as described in IEEE 1547 subsection ~~4.6.14.10.3~~.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Duke plans to review design document and equipment specification to ~~verify an inbuilt function or~~ identify the interconnection device that provides the cease-to-energize function. The existing inspection and commissioning process tests to verify the device meets the performance requirement.

~~This section is ready to be implemented.~~

SECTION 4.6 – CONTROL CAPABILITY REQUIREMENTS

Duke Energy will consider if there is a need to clarify any technical points for the final version of the guideline, but the expectation is that the capabilities in the following sections will be adopted as written.

Duke accepts the requirements in the following Standard sections as written:

4.6.1 Capability to disable permit service

4.6.2 Capability to limit active power

4.6.3 Execution of mode or parameter changes

This section of the Standard applies to all DER 250 kW or greater or DER with a local DER communication interface.

4.6.1 Capability to disable permit service

For UDER, Duke Energy is still considering implementing the permit service at the inverter or disconnecting at the local EPS. ~~The expectation is that Standard compliant inverters will have this capability inbuilt.~~

Application to RDER has not been assessed. ~~The expectation is that Standard compliant inverters will have this capability inbuilt, but Duke will not use it at this time. Future dispatch or emergency response functionality could possibly require this functionality for system reliability.~~

~~Duke's current policy requires a utility owned interconnection recloser for UDER >= 1MW. In this case, the permit service is implemented by controlling the utility owned recloser. For DER >= 250kW and <1MW, Duke allows the option of installing the small DG interface (automation controller) instead of the utility owned recloser. In this case, the permit service is implemented at the DER unit through the small DG interface.~~

Interoperability requirements: The present automation controller implementation includes a disable permit service control. The automation controller has the capability to provide a limit active power Analog Output sent via SCADA to control active power.

Verification and test requirements: Duke will review UL certification tests, type tests, design documents, and equipment specifications to identify the capability of the DER to meet this performance requirement.

~~Duke's current policy requires a utility owned interconnection recloser for UDER >= 1MW. In this case the~~

~~permit service is implemented by controlling the utility owned recloser. For DER $\geq 250\text{kW}$ and $\leq 1\text{MW}$, Duke allows the option of installing the small DG interface instead of the utility owned recloser. In this case, the permit service is implemented at the DER unit through the small DG interface.~~

4.6.2 Capability to limit active power

Active power limits can be static or dynamic. Static limits are fixed and ~~Note that 4.6.2~~ is essentially part of the system impact study (SIS) process now because the maximum active power capacity (import or export) is often calculated during the SIS if the requested DER capacity is not possible without upgrades. The Standard defines the active power limit as a percentage of the Nameplate Active Power Rating. Duke interprets the referenced rating as the Nameplate Active Power Rating at unity power factor. Consider too that the active power limit is manually set and Duke does not have the capabilities to adjust the limit based on time of day, load, or other variables. **Adjusting the limit in real time is a dynamic limit.**

Duke does not plan to implement real-time control during the initial implementation of the Standard. Significant technical studies are required to address concerns and consider remote real-time control of the active power limit. However, it is reasonable to make provision for this potential capability when designing the monitoring and control capabilities of the communication interface.

~~Implementation of this section requires publishing the final technical position.~~

SECTION 4.7 – PRIORITIZATION OF DER RESPONSES

Duke accepts the requirements in the Standard and ~~Duke Energy~~ expects IEEE 1547-2018 compliant inverters to meet all prioritization requirements of this section of the Standard.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Duke plans to review UL certification testing, type tests results, and design documents to evaluate if a DER can meet this requirement.

~~This section is ready to be implemented.~~

SECTION 4.8 – ISOLATION DEVICE

Duke Energy **accepts the requirements in the Standard and** requires isolation devices per the Interconnection Agreement, Method of Service Guidelines, **Requirements for Electric Service and Meter Installations (the White Book)**, and other interconnection documents. This is a current requirement that is unchanged by IEEE 1547-2018.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Existing site evaluation and inspection shall satisfy verification for this requirement.

~~This section is ready to be implemented.~~

SECTION 4.9 – INADVERTENT ENERGIZATION OF THE AREA EPS

Duke Energy requires DER not to energize the utility EPS when the utility EPS is de-energized, ~~therefore accepts the Standard~~. When there is a planned and designed intentional island, per Section 8.2 Intentional Islanding, that configuration is not considered inadvertent.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Duke will only accept type-tested DER for small scale installations like RDER. For UDER, the existing inspection and commissioning process covers this requirement.

~~This section is ready to be implemented.~~

SECTION 4.10 – ENTER SERVICE

Duke Energy requires the DER to meet the requirements of all the following subsections:

4.10.2 Enter service criteria

4.10.3 Performance during entering service

4.10.4 Synchronization

Section 6.6 of the Standard is also encompassed by the requirements of Section 4.10.

4.10.2 Enter service criteria and 4.10.3 Performance during entering service

When entering service, the DER shall not energize the Area EPS until the following conditions are met at the RPA (these are the defaults in the Standard):

Enter service value	Parameter Label	Setting
Minimum Voltage	ES_V_LOW	≥ 0.917 p.u.
Maximum Voltage	ES_V_HIGH	≤ 1.05 p.u.
Minimum Frequency	ES_F_LOW	≥ 59.5 p.u.
Maximum Frequency	ES_F_HIGH	≤ 60.1 p.u.

Note: The parameter labels are based on the publicly available EPRI technical update document number 3002020201, Common File Format for Distributed Energy Resources Settings Exchange and Storage. EPRI, Palo Alto, CA: 2020.

The final UDER settings are still under evaluation. Duke will compare the final voltage trip and ride through settings for UDER with the Standard default settings. Assuming they are compatible, UDER will adopt the same Standard default values.

The DER shall not enter or return to service or ramp faster than the times stated below. ~~The Standard allows an optional A-randomized time delay, but that option is not used and shall be Off. is optional and not currently used within the Duke system.~~ As noted in the standard, DER increasing active power steps greater than 20% of Nameplate Active Power rating shall require approval during the system interconnection study process.

Time Delay	Parameter Label	RDER setting (seconds)	UDER setting (seconds)
Enter Service Delay	ES_DELAY	300	300
Enter Service Ramp Period	ES_RAMP_RATE	300	300
Enter service randomized delay	ES_RANDOMIZED_DELAY	Off	Off

While the active power is ramping during the enter service period, the reactive power shall follow the configured mode and settings.

When connected in parallel with the Area EPS, energy storage DER (ESS) active power rate of change is dependent on the Configuration Active Power Rating per the table below:

Rate of Change Duration	Parameter Label	RDER setting (seconds)	UDER setting (seconds)
ESS ≤ 1 MW	None	2	n/a
ESS > 1 MW	None	n/a	ESS MW range / (2 MW/sec)

The ESS MW range is the sum of the charge and discharge capability.

4.10.4 Synchronization

Duke Energy accepts the requirements in the Standard as written.

Interoperability requirements: No specific requirements for ~~this section~~ these sections.

Duke will evaluate if there is value in monitoring the enter service settings.

Verification and test requirements: For 4.10.2 and 4.10.3, Duke plans to verify the enter service and return to service settings in the field. The existing inspection and commissioning process tests to verify DER meets this requirement. For 4.10.4, Duke plans to review UL certification tests, type tests, and design documents to evaluate DER's synchronization capability meeting this requirement. The on-off test during commissioning will field verify DER's synchronization capability.

Implementation of this section requires publishing the final technical position and applying the interoperability functionality in the local interface.

SECTION 4.11 – INTERCONNECT INTEGRITY

Duke accepts the requirements in the Standard as written for Duke Energy requires the DER to meet the requirements of all the following subsections:

4.11.1 Protection from electromagnetic interference

4.11.2 Surge withstand performance

4.11.3 Paralleling device

Duke Energy does not have additional clarifications of these subsections.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: They standard type-testing is satisfactory for Duke.

~~This section is ready to be implemented.~~

SECTION 4.12 – INTEGRATION WITH AREA EPS GROUNDING

Duke accepts the requirements in the Standard and; that the grounding scheme of the DER interconnection shall be coordinated with the ground fault protection of the Area EPS. Duke's system is multi-grounded and the DER facilities and design must be compatible with the EPS. Each interconnection is reviewed for ground fault protection and for limiting the potential for creating over-voltages on the Area EPS.

Approved distribution connected utility scale DER transformer winding configurations are listed below. Therefore, configurations that are not listed are not approved. It is possible for an IC to submit another winding configuration, however the technical review will significantly delay evaluation of the IR.

Primary Winding Type (HV)	Secondary Winding Type (LV)	Zero Seq Maintained PCC to POC	Allowed for DER Interconnection	
			Inverter	Rotating
Wye-grounded	Wye-grounded	Yes, (w/4-wire LV)	Yes	Yes
Wye-grounded	Wye	No	Yes	No
Wye-grounded	Delta	No	No	Yes

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Duke plans to review the design document to evaluate if a DER can meet this requirement. The existing inspection and commissioning test process will cover this.

~~This section is ready to be implemented.~~

SECTION 5.2 – REACTIVE POWER CAPABILITY OF THE DER

Whether or not reactive power capability or voltage control is initially used for the DER, each DER shall submit the required reactive power capability information. This provides the information when it is most readily available and can be recorded in the event that it is needed later.

For categories related to reactive power capability and voltage regulation performance requirements, Duke Energy plans to require the following performance category:

Voltage and Reactive Power Category B

Category B requires a DER reactive power injection capability (lagging) of 44% of nameplate apparent power rating and 44% absorption capability (leading) of nameplate apparent power rating as defined in the Standard. The Standard adopted “44%” as the injection capability for 0.90 pf, but the percentage is actually slightly less, 43.6%. Duke will consider capabilities 43.6% and higher also meet the intent of the 44% requirement. As a good practice, Duke recommends that all facilities be designed to operate at these pf ratings should the situation arise over the life of the facility that the facility would want this capability.

Because the capability curve limit must be satisfied, the vector sum of the active and reactive powers must not exceed the apparent power capability². The reactive capability shall be provided on an inverter capability curve (P-Q graph) and shall be based at the rated voltage of the device (1 pu) and an ambient temperature of 35° C. The DER may choose to submit reactive capability data on a higher ambient temperature basis, however that data will still be applied as the 35° C capability (Duke cannot temperature adjust manufacturer data).

Because operating points on the chart can be difficult to accurately determine, it is recommended that the DER provide the numerical data that defines critical points on the capability curve. Those points include the Nameplate and Configuration apparent, active, and reactive power ratings at the leading, lagging, and unity power factors.

Some facilities have operational, design, or other limitations that prevent utilization of the full reactive capability of the device(s). If that is the case, the DER shall specify any factors that limit or de-rate the output of the generator (e.g., collector system voltage limits, auxiliary voltage limits, net meter load voltage limits, current limits, and specific ambient temperature conditions). If no limitations are submitted, then Duke will consider that the facility has no reactive capability limitations. Duke recommends submittal of a facility capability curve that includes any limitations.

Supplemental Devices

If the DER includes supplemental devices, capability data must be provided for each device at rated voltage of the device and an ambient temperature of 35° C. Subject to the same conditions above, the DER may elect to submit data at a higher ambient temperature. For a dynamic device, capable of varying output magnitude, a capability curve must be provided with a brief written description and an acceptable power flow model of the device. If the supplemental device is static (i.e. a fixed capability), then a curve is not

² See the EPRI document “Understanding Watt and Var Relationships in Smart Inverters”, 3002015102

required, but the appropriate capability data must be provided and the type of device identified. Additionally, if there are multiple devices that form the complete DER, a composite capability curve that includes all sources, loads, and supplemental devices shall be provided.

Again, any limitations that prevent the full reactive capability of the device(s) to be utilized shall be specified and Duke recommends submittal of a facility capability curve that includes the limitations.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Duke plans to evaluate design documents and equipment specifications to determine reactive power capability. A field test may be required for DER to prove its reactive power capability. Duke expects to follow the commissioning tests requirements in IEEE 1547.1 to cover this topic.

~~This section is ready to be implemented.~~

SECTION 5.3 – VOLTAGE AND REACTIVE POWER CONTROL

Listed below are the Standard voltage and reactive power control options and the default status for Duke interconnections:

Control Mode	Default Status
Constant power factor (fixed pf)	On, 1.0 pf
Constant reactive power (fixed VAR)	Off
Voltage-reactive power (Volt-VAR)	Off
Active power-reactive power (Watt-VAR)	Off

Constant reactive power is not thought to be a particularly useful control mode. Constant power factor is the broad category of control that includes unity power factor, which can be useful, but is limited by operating at a control point that is not based on feeder conditions. Duke is in the process of performing studies that will focus on voltage-reactive power mode and active power-reactive power mode for UDER. The Duke study will evaluate the application and consequences of these functions.

Part of the study effort is to determine if voltage regulation functions should be activated and how they should be configured. Before using these functions on a widespread basis, Duke Energy will evaluate the system impacts, identify any unanticipated effects, and then assess the control modes and settings. Because the impact of UDER reactive injection can be large, Duke limits the reactive capability that can be used for reactive power control to 0.95 power factor.

In North and South Carolina utility scale solar, UDER, is the majority of the solar capacity installed. Therefore, study efforts will focus on that type of facility. In due time, there should be some consideration for residential-scale inverters as well. The reactive control method and settings should consider existing operational requirements as well as mitigation of the high voltages that can occur with the addition of DER. No change can be made on one part of the system that does not affect another part. Therefore, the study will also consider the magnitude of influence the inverter has on voltage, reactive power flow impacts, remediation of impacts, and controlling the impact on the transmission system. Distribution Providers

must comply with agreements and requirements of the transmission entities. As such, an evaluation of transmission impacts is important.

Significant technical studies are required to evaluate these functions and analyze the consequences. The studies began at the end of 2019 and will continue in 2021. This will continue to be an agenda item for the TSRG meetings will focus on the most useful control modes and settings that are applied locally in the inverter and are autonomous. **The plan is to implement the Standard in phases. In this case, reactive power control will be fixed at unity power factor for the initial phase of implementation but may be implemented in a later phase.**

Duke Energy has reviewed and considered all TSRG and submitted comments up to the date of this revision.

Interoperability requirements: There will be few, if any, requirements for fixed power factor DER. For other control modes, the interoperability requirements align with those in the EPRI document, Common File Format for Distributed Energy Resources Settings Exchange and Storage. EPRI, Palo Alto, CA: 2020. 3002020201.

Verification and test requirements: To verify DER compliance to this requirement, Duke will require evaluation of the volt-var settings and field settings verification. Due to complication of performing voltage tests in the field, Duke does not plan to require field commissioning test on this topic. Operational data may be required to evaluate the DER's performance meeting this requirement.

Additional analysis must be performed before finalizing the Verification and test requirements.

Implementation of this section requires publishing the final position, applying the interoperability functionality in the local interface, and integrating verification requirements into the overall commissioning test program.

SECTION 5.4 – VOLTAGE AND ACTIVE POWER CONTROL

The main requirement here involves subsection 5.4.2, Voltage-active power mode. The voltage-active power mode serves as a backup to voltage control. Should an unexpected high voltage condition arise, or the voltage cannot be controlled by the local reactive resources, the voltage-active power control will reduce the DER active power to assist with voltage control.

The default status for Voltage-active power control is Off.

The settings and specifications for voltage-active power control are included with the study discussed for Section 5.3. **The plan is to implement the Standard in phases. In this case, volt-watt control will be Off for the initial phase of implementation but may be implemented in a later phase.**

Interoperability requirements: The interoperability requirements align with those in the EPRI document, Common File Format for Distributed Energy Resources Settings Exchange and Storage. EPRI, Palo Alto, CA: 2020. 3002020201.

Even with autonomous operation there will be some requirements to communicate the mode and possibly other information. Because those requirements are not known at this time, Duke must perform additional analysis and interface testing for autonomous operation.

Duke has the initial I/O points for active power control. The SCADA interface required and operations and functional requirements are still to be determined.

In the future, there may be value in providing the necessary controls for remote utility control. That is second priority to autonomous operation, but that would require even more controls and monitoring.

While the mode can be enabled/disabled with a Binary Output, separate Analog Outputs must be used to set the individual control setpoints.

Verification and test requirements: To verify DER compliance to this requirement, Duke will require evaluation of the volt-watt settings and field settings verification. Due to complication of performing voltage tests in the field, Duke does not plan to require field commissioning test on this topic. Operational data may be required to evaluate the DER's performance meeting this requirement.

Additional analysis must be performed before finalizing the Verification and test requirements.

Implementation of this section requires publishing the final position, applying the interoperability functionality in the local interface, and integrating verification requirements into the overall commissioning test program.

SECTION 6.2 – AREA EPS FAULTS AND OPEN PHASE CONDITIONS

Duke accepts the requirements in the Standard.

~~Duke Energy has not determined the guidelines for this section. While the Standard may be accepted as written, there may need to be clarifications.~~

~~There is a possibility that these requirements could be impacted by This is a sub-task of an ongoing project involving the Protection and Transmission Planning groups. There is an enormous effort to model the system, perform iterative studies, perform the research, and evaluate protection settings. Duke Energy is working to determine the best DER recloser protection elements to optimize protection and ride-through performance and establish the abnormal operating performance Categories. Since the plan is to implement the Standard in phases, if anything does impact the current plan, then any changes could be considered for a later phase.~~

Interoperability requirements: No specific requirements for this section.

~~Duke Energy must evaluate if there are any interoperability requirements for this section.~~

Verification and test requirements: The existing inspection and commissioning process covers the verification of this requirement. Duke plans to continue the practice and refine the process as necessary following the commissioning test requirements in IEEE 1547.1.

Implementation of this section requires publishing the final position, applying the interoperability functionality in the local interface.

SECTION 6.3 – AREA EPS RECLOSING COORDINATION

Duke accepts the requirements in the Standard as written.

~~Duke Energy has not determined the guidelines for this section. While the Standard may be accepted as written, there may need to be clarifications.~~

~~There is a possibility that these requirements could be impacted by This is a sub-task of~~ an ongoing project involving the Protection and Transmission Planning groups. There is an enormous effort to model the system, perform iterative studies, perform the research, and evaluate protection settings. Duke Energy is working to determine the best DER recloser protection elements to optimize protection and ride-through performance and establish the abnormal operating performance Categories. ~~Since the plan is to implement the Standard in phases, if anything does impact the current plan, then any changes could be considered for a later phase.~~

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: For large scale DER that is equipped with a Duke PCC recloser, such coordination will be considered under the Duke Energy DER Enterprise Standards. For other DER, Duke will follow the commissioning tests requirements in IEEE 1547.1.

Implementation of this section requires publishing the final position.

SECTION 6.4.1 – MANDATORY VOLTAGE TRIPPING REQUIREMENTS

Duke Energy has not determined the guidelines for this section.

This is a sub-task of an ongoing project involving the Protection and Transmission Planning groups. There is an enormous effort to model the system, perform iterative studies, perform the research, and evaluate protection settings. Duke Energy is working to determine the best DER recloser protection elements to optimize protection and ride-through performance and establish the abnormal operating performance Categories. As placeholders, the present trip setpoints are added to the Guidelines.

Consensus was reached with Transmission System Planning and Operations for POI Recloser voltage and frequency settings and time delays that provide adequate ride-through for BES events. The team is still reviewing the impact to system protection with the proposed settings.

For new DER installations, the present voltage tripping setpoints are provided in the table below as placeholders and are not final.

Parameter	Voltage	Time
Undervoltage, UV Level 1	0.88 pu	10 cycles
Undervoltage, UV Level 2	0.5 pu	6 cycles
Overvoltage, OV Level 1	1.1 pu	10 cycles
Overvoltage, OV Level 2	1.2 pu	6 cycles

Interoperability requirements: To be determined.

It is expected that these values will be set and not changed remotely, however this position must be evaluated by Duke. Because these are critical protection setpoints, remote visibility of the setting would be a beneficial capability. Because requirements are not known at this time, Duke must perform additional analysis before establishing interoperability requirements. Note that this setting is incorporated in SUNSPEC MODBUS.

Verification and test requirements: The existing inspection and commissioning process covers the voltage trip settings field verification and Duke plans to continue that practice. Due to complication of performing abnormal voltage tests in the field, Duke plans to perform design evaluation and installation evaluation for the purpose of evaluating conformance of the DER, and currently does not plan to require field commissioning tests on this topic. Operational data collection after a DER or system event may be required to validate proper DER operation. IEEE 1547.1-2020 suggests signal injection test method may be considered if the DER has the provision for this method. Adjustment of the shall-trip settings may be made if verification of the mandatory trip function is required.

Implementation of this section requires publishing the final position and applying the interoperability functionality in the local interface.

SECTION 6.4.2 – VOLTAGE DISTURBANCE RIDE-THROUGH REQUIREMENTS

Duke Energy has not determined the guidelines for this section, but these requirements are being developed concurrently with Section 6.4.1 – Mandatory voltage tripping requirements.

See Section 1.4 for the abnormal performance category.

Interoperability requirements: To be determined.

It is expected that these values will be set and not changed remotely, however this position must be evaluated by Duke. Because these are critical protection setpoints, remote visibility of the setting would be

a beneficial capability. Because requirements are not known at this time, Duke must perform additional analysis before establishing interoperability requirements. Note that this setting is incorporated in SUNSPEC MODBUS.

Verification and test requirements: To verify DER compliance, Duke will require evaluation of the DER ride-through settings and field setting verification. Due to complication of performing abnormal voltage tests in the field, Duke plans to perform design evaluation and installation evaluation for the purpose of evaluating conformance of the DER, and currently does not plan to require field commissioning tests on this topic. Operational data collection after a DER or system event may be required to validate proper DER operation. IEEE 1547.1-2020 suggests signal injection test method may be considered if the DER has the provision for this method. Adjustment of the shall-trip settings may be made if verification of the mandatory trip function is required.

Implementation of this section requires publishing the final position and applying the interoperability functionality in the local interface.

6.4.2.6 Dynamic voltage support

At least one Duke region requires dynamic reactive compensation for transmission connected DER. Application for the distribution system is still under evaluation.

SECTION 6.5.1 – MANDATORY FREQUENCY TRIPPING REQUIREMENTS

Duke Energy has not determined the guidelines for this section, but these requirements are being developed concurrently with Section 6.4.1 – Mandatory voltage tripping requirements. As placeholders, the present trip setpoints are added to the Guidelines.

For new DER installations, the present frequency tripping setpoints are provided in the table below.

Parameter	Frequency	Time
Underfrequency, UF	57 Hz	10 cycles
Overfrequency, OF	60.8 Hz	10 cycles

Interoperability requirements: To be determined.

It is expected that these values will be set and not changed remotely, however this position must be evaluated by Duke. Because these are critical protection setpoints, remote visibility of the setting would be a beneficial capability. Because requirements are not known at this time, Duke must perform additional analysis before establishing interoperability requirements. Note that this setting is incorporated in SUNSPEC MODBUS.

Verification and test requirements: The existing inspection and commissioning process covers the frequency trip settings field verification and Duke plans to continue that practice. Due to complication of performing abnormal frequency tests in the field, Duke plans to perform design evaluation and installation evaluation for the purpose of evaluating conformance of the DER, and currently does not plan to require field commissioning tests on this topic. Operational data collection after a DER or system event may be required to validate proper DER operation. IEEE 1547.1-2020 suggests signal injection test method may be considered if the DER has the provision for this method. Adjustment of the shall-trip settings may be made if verification of the mandatory trip function is required.

Implementation of this section requires publishing the final position and applying the interoperability functionality in the local interface.

SECTION 6.5.2 – FREQUENCY DISTURBANCE RIDE-THROUGH REQUIREMENTS

For sections 6.5.2.1 through 6.5.2.4, concerning frequency ride-through:

Duke Energy has not determined the guidelines for this section, but these requirements are being developed concurrently with Section 6.4.1 – Mandatory voltage tripping requirements.

The Standard also includes several subsections related to frequency. Although Duke Energy considers these requirements mainly as functional specifications for the inverter, Duke Energy does have additional requirements or clarifications.

6.5.2.5 Rate of change of frequency (ROCOF)

~~UL certification testing should verify the inverter will ride through a 3 Hz/s excursion in accordance with abnormal operating performance Category III. That being the case, no generator on the utility system shall intentionally trip for ROCOF using protective relaying or DER controller functions. DER tripping for ROCOF, if available, should be off or disabled. The DER shall certify that protective relay settings & controller settings do not intentionally trip for ROCOF.~~ Duke requires DER ride through a 3 Hz/s frequency excursion in accordance with abnormal operating performance Category III. DER tripping for ROCOF should be off, disabled, or above 3 Hz/s and within the ROCOF capability of the DER equipment. The DER shall certify that protective relay settings and DER controls are not designed or configured in such a way as to interfere with ROCOF performance.

This function, either at the inverter or the utility PCC recloser, is still under evaluation. Duke anticipates adopting the 1547 requirements if that is supported by the ongoing project.

6.5.2.6 Voltage phase angle changes ride-through

The UL 1741 SB certification shall be considered sufficient for individual inverter based DER devices meeting ride through requirements for this function. The DER shall certify that protective relay settings & controller settings of the completed DER facility do not intentionally trip for the voltage phase angle changes specified by the Standard.

This function, either at the inverter or the utility PCC recloser, is still under evaluation as part of an ongoing project involving the Protection and Transmission Planning groups. Duke anticipates adopting the requirements above if that is supported by the ongoing project.

6.5.2.7 Frequency-droop (frequency-power) capability

Duke accepts the default operation conditions and settings in the Standard as written:

Operation for low-frequency conditions	Mandatory, On
Operation for high-frequency conditions	Mandatory, On

Parameter	Setting
dbOF, dbUF (Hz)	0.036
kOF, kUF	0.05
T-response (small-signal) (s)	5

At this time, a frequency deadband of 36 mHz and a droop of 5% are considered acceptable for inverter and non-inverter sources. As the mix of generation sources transition over time, it may be necessary to transition to a lower values in the future to maintain EPS reliability.

This function is still under evaluation as part of an ongoing project involving the Protection and Transmission Planning groups. Per Standard table 24, a specification of the droop, deadband, and associated parameters is required for Category II and III.

6.5.2.8 Inertial response

Duke Energy has not determined the guidelines for this subsection. This capability is not required by the Standard but is permitted.

Interoperability requirements: To be determined.

It is expected that these values for Section 6.5.2 will be set and not changed remotely, however this position must be evaluated by Duke. Because these are critical protection setpoints, remote visibility of the setting would be a beneficial capability. Because requirements are not known at this time, Duke must perform additional analysis before establishing interoperability requirements. Note that this setting is incorporated in SUNSPEC MODBUS.

Verification and test requirements: To verify DER compliance, Duke will require evaluation of the DER ride-through settings and field setting verification. Due to complication of performing abnormal frequency tests in the field, Duke plans to perform design evaluation and installation evaluation for the purpose of evaluating conformance of the DER, and currently does not plan to require field commissioning tests on this topic. Operational data collection after a DER or system event may be required to validate proper DER operation. IEEE 1547.1-2020 suggests signal injection test method may be considered if the DER has the provision for this method. Adjustment of the shall-trip settings may be made if verification of the mandatory trip function is required. Also note for the individual functions, that Duke reserves the right to verify that protective relay settings & controller settings do not interfere with or prevent proper performance the various ride-through requirements.

Implementation of this section requires publishing the final position and applying the interoperability functionality in the local interface.

SECTION 7.2.2 – RAPID VOLTAGE CHANGES

Duke has an existing process that is part of the system impact study to assess the risk of Rapid Voltage Changes (RVC) and require mitigation if necessary. Duke considers that the existing RVC criteria, ~~stated below, is consistent with the Standard. and does not plan further evaluation.~~

Rapid Voltage Change analysis is performed for all facilities 1 MW capacity and larger using appropriate modeling techniques (e.g. PSCAD). The study evaluates the effect of transformer energization, with the voltage change evaluated anywhere on the circuit to assure a change no greater than 3%. The study will consider combinations of residual flux and closing angle that cause a large voltage dip. When the RVC limit cannot be met without some form of mitigation, the method of mitigation must also limit inrush such that the RVC is no greater than 3%.

A Controlled Switching Device (CSD) shall also limit the transformer inrush voltage change to 3%. For CSDs that must learn or be calibrated in order to provide maximum inrush current reduction, a 6% RVC limit is temporarily applicable only during that limited calibration time (the higher inrush is only expected for the minimum amount of closes needed to calibrate the CSD). The higher limit only applies to special situations such as CSD commissioning, or following breaker maintenance or replacement, or the CSD undergoes some upgrade or repair and does not apply to normal operation conditions.

Interoperability requirements: A power quality meter is currently required for DER of 1 MW or greater and no additional requirements are proposed for the revised Standard. ~~To be determined.~~

~~Based on the type of inrush mitigation used, there could be some status points that are useful for situational awareness. Because requirements are not known at this time, Duke must perform additional analysis before establishing interoperability requirements.~~

~~Verification and test requirements: The installation evaluation is currently included in the scope of Duke's interconnection inspection process, but the performance of the inrush mitigation is not currently tested. A power quality meter is required for the field tests. Duke plans to evaluate the DER RVC impact and mitigation performance by reviewing the data collected during the commissioning test (such as cease-to-energize test). Duke will develop a test procedure and criteria to evaluate the performance of a RVC mitigation solution as part of the commissioning tests.~~

Verification and test requirements: The installation verification is currently included in the scope of Duke's interconnection inspection process. Duke will develop a test procedure and criteria to evaluate the performance of an RVC mitigation solution as part of the commissioning tests.

~~Implementation of this section requires applying the interoperability functionality in the local interface and integrating verification requirements into the overall commissioning test program.~~

SECTION 7.2.3 – FLICKER

Duke Energy **accepts the** requirements ~~as written~~ in the Standard. Note that Duke also applies IEEE 1453 recommended practices.

Interoperability requirements: **A power quality meter is currently required for DER of 1 MW or greater and no additional requirements are proposed.**~~No specific requirements for this section.~~

Verification and test requirements: Duke plans to review design document and equipment specification to evaluate the potential flicker cause DER. A power quality meter is required for the field tests. Duke plans to follow the commissioning tests requirements in IEEE 1547.1. Operational data collection after a DER or system event may be required to validate proper DER operation.

~~This section is ready to be implemented.~~

SECTION 7.3 – LIMITATION OF CURRENT DISTORTION

Duke Energy **accepts the** requirements ~~as written~~ in the Standard. The industry has found that the inverter designs are reaching and exceeding the harmonic monitoring capabilities of existing measurement devices. Therefore, Duke Energy requires the DER owner to ~~mitigate all order harmonics to no greater than 0.3%~~ **mitigate harmonics greater than the 50th order to no greater than 0.3% of the fundamental DER rated current at the RPA. In addition, any Adverse Operating Effects must be addressed as noted in the DER Interconnection Agreement. if the harmonics affect other customers.** Harmonic limits shall be aggregated and applied during the DER hours of operation, ~~not just at peak or rated output.~~

Interoperability requirements: No specific requirements for this section. Installation of a power quality meter is already part of the required design for DER 1 MW and greater.

Verification and test requirements: Duke plans to follow the commissioning tests requirements in IEEE 1547.1.

~~This section is ready to be implemented.~~

SECTION 7.4.1 – LIMITATION OF OVERVOLTAGE OVER ONE FUNDAMENTAL FREQUENCY PERIOD

Duke Energy **accepts the** requirements as written in the Standard.

Part of 7.4.1 is based on the inverter design and operation and part is based on the specific design of the interconnection and the Area EPS itself. The ability of the inverter to detect and limit overvoltage will be verified by UL certification testing. However, the DER facility must still be analyzed during system impact study to verify the impact of the combined inverter and Area EPS is below the limits of the Standard. The limits defined in parts a) and b) must be verified by power system study. **In addition, any Adverse Operating Effects must be addressed as noted in the DER Interconnection Agreement.**

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Duke plans to rely on UL certification testing, review type tests results, and examine design documents to evaluate the potential overvoltage contribution from DER. Duke plans to develop a test procedure and criteria for transient overvoltage during the commissioning test. A power quality meter is required for the field tests. Duke plans to follow the commissioning tests requirements in IEEE 1547.1.

~~This section is ready to be implemented.~~

SECTION 7.4.2 – LIMITATION OF CUMULATIVE INSTANTANEOUS OVERVOLTAGE

~~Duke Energy has not determined the guidelines for this section.~~ More industry experience or analysis could be essential to address this issue. Duke does not plan to implement this section until IEEE 1547.1 is revised and UL 1741 certification tests include this verification. At that time, Duke expects to **accept the** requirements as written in the Standard.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Duke plans to review type tests results and design documents to evaluate the potential overvoltage contribution from DER. Duke plans to develop a test procedure and criteria for transient overvoltage during the commissioning test. A power quality meter is required for the field tests. Duke plans to follow the commissioning tests requirements in IEEE 1547.1.

~~Implementation of this section requires publishing the final technical position.~~

SECTION 8.1 – UNINTENTIONAL ISLANDING

Duke Energy has not determined the guidelines for this section.

This is a sub-task of an ongoing project involving the Protection and Transmission Planning groups. There is an enormous effort to model the system, perform iterative studies, perform the research, and evaluate protection settings. Duke Energy is working to determine the best DER recloser protection elements to optimize protection and ride-through performance and establish the abnormal operating performance Categories. As placeholders, the expected requirement is noted below.

Duke accepts the requirements in the following Standard sections as written:

8.1.1 General

8.1.2 Conditional extended clearing time

8.1.3 Area EPS with automatic reclosing

If there is the option to activate or deactivate the anti-islanding function, it shall be activated or the status On.

The standard clearing time for an unintentional island is 2 seconds. The DER shall identify and provide the method of islanding detection* used for all DERs above 250 kW.

Interoperability requirements: No control points are expected. Need to determine if any monitoring is necessary.

Verification and test requirements: To be determined.

* Such as one of the six groups listed in section 2.3 Generic Island Detection Groups and Response Models of Inverter-Onboard Islanding Detection Assessment: Final Project Report. EPRI, Palo Alto, CA:2020. 3002014051.

SECTION 10.1, 10.7, 10.8, 10.9 – GENERAL INTEROPERABILITY AND PROTOCOL REQUIREMENTS

These sections of the Standard relate more directly to the hardware requirements of the DER interface. Duke Energy adopts these requirements of these sections as written in the Standard.

Duke requires an interconnection recloser interface for DER rated $\geq 1\text{MW}$ and the default protocol is DNP3. If mutually agreed upon by the Area EPS operator and DER operator, Modbus may be used as the only exception to DNP3.

For DER $\geq 250\text{kW}$ and $<1\text{MW}$, Duke requires an automation controller interface and with Modbus protocol.

In all applications, there shall be one point of interface between a single Duke automation controller and a single DER automation controller or a single DER source (e.g., one individual inverter).

Verification and test requirements: Operation of the hardware, point mapping, information exchange, and communication of data will be part of the commissioning tests requirements.

SECTION 10.2, 10.3, 10.4, 10.5, 10.6 – DATA, MONITORING, AND CONTROL NAMEPLATE AND CONFIGURATION INFORMATION

These sections of the Standard contain both general and specific data, monitoring, and control information. Sections 10.3 and 10.4 primarily contain general information such as DER ratings and configuration characteristic data that does not change often, if ever. This is the basic information provided by each DER interface. On the other hand, 10.5 and 10.6 provide real-time monitoring, control, and status information that is dependent upon the specific functions in use. Therefore, the specific parameters in the interface point map will be based on the Standard and the DER functions that are enabled. Each section of the Guidelines contains an “Interoperability requirements” subsection that defines the associated data, monitoring, and control requirements in addition to any Standard requirements.

Verification and test requirements: Operation of the hardware, point mapping, information exchange, and communication of data will be part of the commissioning tests requirements.

Additional discussion about ratings and limits:

Sections 10.3 and 10.4 ~~These sections~~ address the two broad types of information available through the local DER communication interface. Section 10.3 specifies various DER ratings and 10.4 specifies configuration settings, which are often more clearly thought of as limits. While there is some commonality, the intent of the nameplate and configuration terms are different.

The following terms are listed in decreasing order of magnitude. The value of each parameter in the list is greater than or equal to the value of the parameter below it:

- Nameplate Apparent Power Maximum Rating
- Configuration Apparent Power Maximum Rating
- Nameplate Active Power Rating (unity power factor)
- Configuration Active Power Rating (unity power factor)

The list above does not address all the terms in the table. Such a specification is not necessary of every term, but helpful to clarify for some. Duke will consider addressing other terms as needed. Consequently, operational limits and settings, such as the Active Power Limit, cannot be greater than the ratings (not applicable to abnormal or protection settings).

Ratings are considered a permanent characteristic of a device or a system and are characterized by:

- Rating is the full capacity of the equipment or system.
 - The rating is the most capacity the system is designed to provide

- Rating represents a continuous capacity. Operation at the Rating can continue for indefinitely long periods without exceeding design limits and without reducing the life or maintenance interval.
 - Also, there can be short-term ratings that are time limited. Operation within the parameter and time limit does not exceed design limits or negligibly reduce the life or maintenance interval.
- Rating is the base upon which other model, analysis, and inverter parameters are referenced.
- Ratings are a common way to identify and classify devices.

Limits are not included in these sections of the Standard. However, their relationship to and differences from ratings are important. Limits are adjustable, provide boundaries not to be exceeded, and are less than or equal to ratings. Limits are characterized by:

- Limits impose boundaries on device operation, often to restrict operation within ratings.
- Limits can be established or defined by contractual, system design, or physical equipment restrictions.
- Limits are set for a controlled variable and must not be exceeded (e.g. boundary condition).
- Limits are often stated as a percent of the rating (therefore necessitating a fixed rating value).

The Nameplate Active Power Rating is an important design parameter for the DER, but also as an important base parameter for modeling. The same for Nameplate Apparent Power Maximum Rating, for some equipment or models, parameters may be specified in terms of percent of Nameplate Apparent Power or Nameplate Active Power Rating. In cases where operation to the full Nameplate Active Power Rating is not acceptable for the application, then the Configuration Active Power Rating can be set to establish a lower rating. While the minimum of these two values sets the overall rating, it can be important to distinguish between these when it comes to equipment specifications and modeling.

UNADDRESSED REQUIREMENTS OF IEEE 1547-2018

The remaining IEEE 1547-2018 clauses and sections not discussed above will be undertaken following the completion of the higher priority topics. Concerning the clauses and sections not addressed in this document, Duke Energy expects that the DER shall conform to the Standard itself as written.

APPENDIX – IEEE 1547-2018 BENCHMARKING

Duke Energy requested that Navigant Consulting, Inc. to facilitate the stakeholder discussion at the January 2020 TSRG meeting and to perform benchmarking. The following table was developed by Navigant Consulting, Inc.

TABLE B.1. BENCHMARKING OF IEEE 1547-2018 FUNCTIONALITIES IMPLEMENTATION

IEEE 1547 Section	Topic	Duke Order (pre-stakeholder)	Minnesota/ Colorado (Xcel Energy)	Ameren / MISO
6.4.2	Voltage disturbance ride-through requirements	1	1	1
5.3	Voltage and reactive power control	1	1	1
6.5.2	Frequency disturbance ride-through requirements	2	1	1
6.4.1	Mandatory voltage tripping requirements (OV/UV)	1	1	2
5.4.2	Voltage-active power control	1	1	2
6.5.2.7	Frequency-droop (frequency-power) capability	2	1	2
6.5.1	Mandatory frequency tripping requirements (OF/UF)	2	1	2
5.2	Reactive power capability of the DER	1	1	
4.5	Cease to energize performance requirement [Reliability]	3	2	
4.6.1	Capability to disable permit service	3	2	
4.6.2	Capability to limit active power	3	2	
4.10.2	Enter service criteria	4	3	2
7.2.2	Power Quality, Rapid voltage change (RVC)	1	3	
4.10.3	Performance during entering service	4	3	
4.10.4	Synchronization	4	3	
4.2	Reference points of applicability (RPA) [Interconnection]	4	3	
6.5.2.5	Rate of change of frequency (ROCOF)	4	4	1
4.10	Enter service [Reliability] // 6.6 Return to service after trip	4	4	2
6.4.2.6	Dynamic voltage support		4	2
4.3	Applicable voltages [Manufacturer]	4	4	
4.11.3	Paralleling device	4	4	
6.2	Area EPS faults and open phase conditions [Reliability]		4	
6.3	Area EPS reclosing coordination [Reliability]		4	

IEEE 1547 Section	Topic	Duke Order (pre-stakeholder)	Minnesota/ Colorado (Xcel Energy)	Ameren / MISO
10.2	Monitoring, control, and information exchange requirements		4	
10.5	Monitoring information		4	
10.1	Interoperability requirements		4	
10.3	Nameplate Information		4	
10.4	Configuration information		4	
10.6	Management information		4	
10.7	Communication protocol requirements		4	
10.8	Communication performance requirements		4	
10.9	Cyber security requirements		4	
11	Test and verification		4	
8.2	Intentional islanding		4	
11.4	Fault current characterization		4	
9	Secondary network		4	
4.6.3	Execution of mode or parameter changes [Manufacturer]		4	
6.5.2.6	Voltage phase angle changes ride-through	2		1
6.4.2.5	Ride-through of consecutive voltage disturbances			1
7.2.3	Power Quality, Flicker	1		
7.4	Limitation of overvoltage contribution	1		
6.5.2.8	Inertial response			
7.3	Limitation of current distortion			
8.1	Unintentional islanding			
4.7	Prioritization of DER responses			
4.8	Isolation device [Interconnection]			
4.11.1	Protection from electromagnetic interference			
4.11.2	Surge withstand performance			
4.12	Integration with Area EPS grounding [Reliability]			
4.13	Exemptions for Emergency Systems and Standby DER			
4.9	Inadvertent energization of the Area EPS [Interconnection]			

Implementation of IEEE 1547-2018 Guidelines for Duke Energy Carolinas and Duke Energy Progress

Duke Energy

Duke Energy Carolinas and Duke Energy Progress

Distributed Energy Technology

DER Technical Standards

Revision 6

October 19, 2021



**Implementation of IEEE 1547-2018 Guidelines for
Duke Energy Carolinas and Duke Energy Progress**

Revision	Date	Description
0	3/31/2020	Initial issue
1	7/21/2020	General update prior to Jul. 2020 TSRG meeting
2	10/28/2020	General update prior to Oct. 2020 TSRG meeting
3	1/20/2021	General update prior to Jan. 2021 TSRG meeting
4	4/28/2021	General update prior to Apr. 2021 TSRG meeting
5	7/20/2021	General update prior to Jul. 2021 TSRG meeting
6	10/19/2021	General update prior to Oct. 2021 TSRG meeting

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INTRODUCTION

Duke Energy seeks to implement smart inverter technical specifications and requirements as defined in the updated IEEE Standard 1547-2018, IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems (IEEE 1547 or the Standard). This document focuses only on the distributed energy resources (DER) connected to the distribution system and not those connected to the transmission or bulk power system (BPS). In North and South Carolina, the implementation of IEEE 1547 is focused on large utility scale DER (UDER) because there had been significant number of those installations. Some of IEEE 1547 requirements are also applicable to the smaller retail and residential DER (RDER). If there are any variations in application of the Standard to UDER and RDER, those conditions will be noted in this document.

Note to the format of this document. This guideline is meant to be a living document. For now, it captures where Duke Energy is in the process of implementing IEEE 1547-2018. This document notes sections of the standard that require no additional analysis or review and those that are under review and those that must still be reviewed. In sections highlighted like this paragraph, there will be a brief discussion of the ongoing work to be concluded to address implementation of that Standard section.

The standard is an inverter Standard and not a utility standard, therefore many parts of the Standard can be implemented by Duke Energy simply by adopting IEEE 1547-2018 as the applicable standard for Duke Energy inverter based interconnections. However, there are some sections of the Standard that require input or specifications from the utility. The Standard specifies inverter capabilities and functions, but not utilization. The purpose of this document is to clarify any additional information for utilization.

The standard is applicable to DER connected at the primary or secondary distribution system voltage levels. However, some of the Standard requirements are based on conditions and issues related to the BES. There can be situations where the aggregate distribution DER capacities are large enough to impact the NERC BES reliability. In those cases, BES requirements are implemented in DER connected to the distribution system. However, these requirements are not directly distribution requirements, but BES requirements applied at the distribution power system level. The interaction between the BES and the distribution system is well covered in the [NERC Reliability Guideline](#): Bulk Power System Reliability Perspectives on the Adoption of IEEE 1547-2018. The guideline recommends that the BPS entities (BA, RC, PC, TP) coordinate with the Distribution Providers (DP) to achieve successful implementation of the Standard.

This Duke Energy Guideline is applicable to DER located in the Duke Energy service territories in North Carolina and South Carolina. The Guidelines have been developed based on input and comments from TSRG stakeholders.

CONSIDERATION OF IEEE 1547 SECTIONS THAT COULD INCREASE INTERCONNECTION CAPABILITY

The following IEEE 1547 controls or functions are the primary functions that could potentially increase the amount of DER capacity (higher penetration) that can interconnect with minimal feeder upgrades:

- i) 4.6.2 Capability to limit active power
- ii) 5.3 Voltage and reactive power control
- iii) 5.4 Voltage and active power control

While power quality issues can still restrict interconnection, the voltage and reactive power controls are a potential mitigation to those issues too.

While there are other inverter functions that improve reliability of the interconnection, the inverter functions listed above would be the primary drivers for adding more DER capacity to a feeder. Therefore, these functions were assigned a higher priority to review and analyze.

CONSIDERATION OF IEEE 1547 SECTIONS THAT IMPACT GRID SUPPORT

In addition to prioritizing assessment of those sections of IEEE-1547 that could increase interconnection capability, the Companies are also prioritizing those sections that could impact grid support. The 2003 version of the standard created reliability concerns by not providing voltage regulating capability and tripping for abnormal system conditions. While the 2014 version addressed some of the grid reliability concerns, 2018 provides even more inverter capabilities. Also, documents such as the NERC Reliability Guideline: Bulk Power System Reliability Perspectives on the Adoption of IEEE 1547-2018 focus “on ensuring reliable operation of the BPS under increasing penetrations of BPS-connected inverter-based resources as well as distributed energy resources (DERs).” One objective of such documents is to encourage timely adoption of the IEEE 1547-2018 that are likely to impact or support the BPS.

The priority of review of the Standard sections identified in the table is consistent with this industry guidance in that many of the first and second priority selected topics were noted in the NERC guideline as well. Sections 4.2 and 4.10.2 are fourth priority for Duke, but that is mainly because these topics are thought to be more straightforward to address and will likely not require significant evaluation. Interoperability was noted by NERC and Duke plans to address that on a topic by topic basis rather than as one stand-alone interoperability topic. In this way, interoperability is addressed concurrent with the technical considerations for each topic.

The following topics are yet unranked by Duke, but they are in the NERC guideline: 6.4.2.7, 6.5.2.8, 8.1, 8.2. Section 6.4.2.7 was added to the Duke list after the NERC guideline review. These were not ranked during the Duke process because of the lower priority placed on them by the TSRG stakeholders and Duke. These are also topics that need more time and investigation by the industry, so addressing some of the better understood and higher prioritized items first is a reasonable path forward.

PRIORITY OF IMPLEMENTING THE IEEE 1547 TECHNICAL SPECIFICATIONS AND REQUIREMENTS

There are many aspects of implementing the Standard that must be considered. The technical specifications and requirements must be understood and assessed to determine if there is a need to clarify any technical points for consistent application across the Duke system. Duke subject matter experts, TSRG stakeholders, NC Public Staff, and industry documents were included in the activity to set priority for the various Standard sections. The areas of the Standard that stand out as most important are the ride through capability and voltage and reactive power controls.

Below is the priority order at this time considering all TSRG input. If there is no priority stated in the list, then the priority of those items is yet to be assigned. Note that the priority group and the assigned Duke identification number¹ for that item are both in the first column. The remaining IEEE 1547-2018 clauses and sections that do not have a priority assigned will be undertaken following the completion of the higher priority topics. The three columns on the far right side of the table summarize the status for the technical, interoperability, and verification and test aspects for each Standard topic. Many of the summaries are not the final decision because the topic requires more analysis and assessment. However, this table still provides a general overview.

¹ Only the prioritized Duke identification numbers represent the sequence of evaluation, and are numbered less than 100. Numbers greater than 100 are temporarily assigned to the topic until that topic is given a specific priority.

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2 **Duke Energy Selected Order of Precedence for IEEE 1547 Sections**

TSRG Priority Order (Duke ID)	IEEE 1547 Section	IEEE 1547-2018 Topic	Technical Position Summary	Interoperability Summary	Test and Verification Summary
1 (DUK-01)	5.2	Reactive power capability of the DER	Category B	No Reqmt	Eval + Comm Test
1 (DUK-02)	5.3	Voltage and reactive power control	Study in progress, constant pf initially	Yes	Eval + Comm Test
1 (DUK-03)	5.4.2	Voltage-active power control	Study in progress, not used initially	Yes	Eval + Comm Test
1 (DUK-04)	7.4	Limitation of overvoltage contribution	Accept 1547 with additional requirements	No Reqmt	Eval + Comm Test
1 (DUK-05)	7.2.3	Power Quality, Flicker	Accept 1547 in conjunction with continued use of IEEE 1453	No Reqmt	Eval + Comm Test
1 (DUK-06)	7.2.2	Power Quality, Rapid voltage change (RVC)	Continue existing criteria and policy	No Reqmt	Eval + Comm Test
2 (DUK-07)	6.4.1	Mandatory voltage tripping requirements (OV/UV)	Have existing setpoints; new 1547 setpoint study in progress	TBD	Eval + Comm Test
2 (DUK-08)	6.5.1	Mandatory frequency tripping requirements (OF/UF)	Have existing setpoints; new 1547 setpoint study in progress	TBD	Eval + Comm Test
2 (DUK-09)	6.4.2	Voltage disturbance ride-through requirements	Study in progress	TBD	Eval + Comm Test
2 (DUK-10)	6.5.2	Frequency disturbance ride-through requirements	Study in progress	TBD	TBD, Eval + Comm Test
2 (DUK-11)	6.5.2.7	Frequency-droop (frequency-power) capability	Evaluation has not begun	No Reqmt	TBD, Eval + Comm Test
2 (DUK-12)	6.5.2.6	Voltage phase angle changes ride-through	Study in progress	No Reqmt	TBD, Eval + Comm Test
2 (DUK-103)	8.1	Unintentional islanding	TBD	Yes	TBD, Eval + Comm Test
3 (DUK-13)	4.5	Cease to energize performance requirement	Accept 1547	No Reqmt	Eval + Comm Test

TSRG Priority Order (Duke ID)	IEEE 1547 Section	IEEE 1547-2018 Topic	Technical Position Summary	Interoperability Summary	Test and Verification Summary
3 (DUK-14)	4.6.1	Capability to disable permit service	Accept 1547, with notes	Yes	Eval + Comm Test
3 (DUK-15)	4.6.2	Capability to limit active power	Accept 1547, static limits	Yes	Eval + Comm Test
4 (DUK-16)	6.5.2.5	Rate of change of frequency (ROCOF)	Study in progress	TBD	Eval + Comm Test
4 (DUK-17)	4.2	Reference points of applicability (RPA)	Accept 1547 ; consider clarifications	No Reqmt	Eval.
4 (DUK-18)	4.3	Applicable voltages	Accept 1547 ; consider clarifications	Yes	Eval.
4 (DUK-19)	4.10.2	Enter service criteria // 6.6 Return to service after trip	Accept 1547 ; consider clarifications	No Reqmt	TBD, Eval + Comm Test
4 (DUK-20)	4.10.3	Performance during entering service	Accept 1547 ; consider clarifications	No Reqmt	Eval + Comm Test
4 (DUK-21)	4.10.4	Synchronization	Accept 1547 ; consider clarifications	No Reqmt	TBD, Eval + Comm Test
4 (DUK-22)	4.11.3	Paralleling device	Accept 1547	No Reqmt	Type Test
5 (DUK-23)	4.9	Inadvertent energization of the Area EPS	Accept 1547	No Reqmt	Eval + Comm Test
5 (DUK-24)	6.3	Area EPS reclosing coordination	Accept 1547 ; consider clarifications; part of ongoing study	No Reqmt	Eval.
5 (DUK-25)	6.2	Area EPS faults and open phase conditions	Accept 1547 ; consider clarifications; part of ongoing study	TBD	Eval + Comm Test
5 (DUK-26)	4.12	Integration with Area EPS grounding	Accept 1547 with clarifications	No Reqmt	Eval.
5 (DUK-27)	4.7	Prioritization of DER responses	Accept 1547	No Reqmt	TBD, Eval + Comm Test
5 (DUK-28)	4.8	Isolation device	Accept 1547 with notes	No Reqmt	Eval + Comm Test

TSRG Priority Order (Duke ID)	IEEE 1547 Section	IEEE 1547-2018 Topic	Technical Position Summary	Interoperability Summary	Test and Verification Summary
5 (DUK-29)	4.11.1	Protection from electromagnetic interference	Accept 1547	No Reqmt	Type Test
5 (DUK-30)	4.11.2	Surge withstand performance	Accept 1547	No Reqmt	Type Test
5 (DUK-31)	4.6.3	Execution of mode or parameter changes	Accept 1547	TBD, Yes	TBD, Eval + Comm Test
- (DUK-101)	9	Secondary network	Duke does not currently have these	No Reqmt	-
- (DUK-102)	11.4	Fault current characterization	TBD	No Reqmt	-
- (DUK-104)	8.2	Intentional islanding	TBD	Yes	-
- (DUK-105)	11	Test and verification	TBD	-	-
- (DUK-106)	10.2	Monitoring, control, and information exchange requirements	TBD	Yes	-
- (DUK-107)	10.5	Monitoring information	TBD	Yes	-
- (DUK-108)	6.4.2.5	Ride-through of consecutive voltage disturbances	TBD	No Reqmt	-
- (DUK-109)	6.4.2.6	Dynamic voltage support	TBD	No Reqmt	-
- (DUK-110)	6.5.2.8	Inertial response	TBD	No Reqmt	-
- (DUK-111)	10.1	Interoperability requirements	TBD	Yes	-
- (DUK-112)	10.3	Nameplate Information	TBD	Yes	-
- (DUK-113)	10.4	Configuration information	TBD	Yes	-
- (DUK-114)	10.6	Management information	TBD	Yes	-
- (DUK-115)	10.7	Communication protocol requirements	TBD	Yes	-
- (DUK-116)	10.8	Communication performance requirements	TBD	Yes	-

TSRG Priority Order (Duke ID)	IEEE 1547 Section	IEEE 1547-2018 Topic	Technical Position Summary	Interoperability Summary	Test and Verification Summary
- (DUK-117)	10.9	Cyber security requirements	TBD	Yes	-
- (DUK-118)	7.3	Limitation of current distortion	Accept 1547	No Reqmt	Type Test
- (DUK-119)	4.13	Exemptions for Emergency Systems and Standby DER	TBD	TBD	-
- (DUK-120)	6.4.2.7	Restore output with voltage ride-through	TBD	No Reqmt	0

LOGISTICS OF IMPLEMENTING OF IEEE 1547-2018

After the technical aspects of each Standard section are understood, Duke Energy can then determine the necessary changes to implement that section. This could vary from taking no action, to updating documentation, to changing work, study, and operational practices. Additionally, a consequence of more inverter functions will be the necessary increase in interoperability requirements as well as DER equipment and DER system verification and testing to confirm design and functional requirements. There are many aspects to consider before implementing each 1547 section. Because the actions to implement each section can vary widely, the implementation will be addressed in each section rather than as a whole for the entire Standard.

It is understood that many of the functions will not be available until IEEE 1547-2018 certified inverters are tested and available to the market. At that time, Duke Energy shall require all inverters to be IEEE 1547-2018 certified. All functions and requirements may not be applicable or implemented at the time the inverters become certified or that Duke Energy requires the certification.

Duke Energy has no plans to implement the new functions of IEEE 1547-2018 for existing inverters. Not only is it not a common practice at Duke to retroactively apply standards, it is really not even a valid option because existing inverters do not have many of the 1547-2018 capabilities and were not tested to UL 1741 SB. If a 1547-2018 function is implemented and there is a comparable IEEE 1547a-2014 function for inverters certified to UL 1741 SA, then Duke Energy and the DER Owner may mutually agree to implement those available functions as needed. Similarly, some functions like voltage and frequency tripping have existed throughout all versions of 1547. Revising pre-existing settings is not considered implementation of a new function.

PLANT REQUIREMENTS

Guidelines must consider how all sections may apply if implemented on a plant-scale with a power plant controller rather than at the individual inverter units. There may need to be some tests for verification that

the plant controller performs the intended functions and that the underlying inverters to not behave contrary to the plant controller configuration or commands.

Note that in the following part of this document, the title of each section is the IEEE 1547-2018 section or subsection number and title.

SECTION 1.4 – GENERAL REMARKS AND LIMITATIONS

Duke accepts the requirements in the Standard.

For UDER, the single point of common coupling (PCC) is located at the boundary between the utility electric power system (EPS) and the local EPS or DER EPS.

The technical specifications and requirements for some performance categories are specified by general technology-neutral categories. For categories related to reactive power capability and voltage regulation performance requirements, Duke Energy requires the following normal performance category:

Voltage and Reactive Power Category B

For categories related to response to Area EPS abnormal conditions, Duke Energy requires the following abnormal operating performance categories:

Synchronous generation	Category I
Induction generation	Mutual agreement
Inverter-based generation	Category III*
Inverter-based storage	Category III*

This section shall be applicable once 1547-2018 inverters are certified and required or if by mutual agreement between Duke Energy and the DER Owner for inverters certified to IEEE 1547a-2014 or UL 1741 SA.

* Final determination for the Category has not been made. More analysis is required and included as part of a study conducted jointly between the Duke Protection and Transmission Planning groups. This work includes a significant effort to model the system, perform iterative studies, and perform research. The main focus is on Category II and that is expected to be the minimum requirement for IBR. With the amendment to IEEE 1547a-2020 approved and many utilities standardizing on Category III, that is the most likely selection.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Independent laboratory certifications that attest to the normal and abnormal categories shall satisfy verification for this requirement.

Implementation of this section requires publishing the final position and integrating verification requirements into the overall commissioning test program.

SECTION 4.2 – REFERENCE POINTS OF APPLICABILITY (RPA)

Duke accepts the requirements in the Standard.

Duke Energy requires the RPA for all performance requirements for UDER to be the PCC (point of common coupling), which is also known as the point of delivery or change of ownership point on the medium voltage side of the DER transformer(s). The RPA for net meter installations is the PoC (point of connection) at the inverter terminals.

See the decision trees in the informative Annex H of the Standard and the decision tree in IEEE 1547.2.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Duke will to review DER design documents to confirm the location of the RPA is correct.

SECTION 4.3 – APPLICABLE VOLTAGES

Duke accepts the requirements in the Standard. The Method of Service Guidelines addresses interconnection voltages.

Interoperability requirements: Applicable voltages are provided to the local DER interface with Duke Energy.

Verification and test requirements: The applicable voltages will be established during the interconnection process. Duke plans to review design document to verify the DER meet this requirement..

SECTION 4.5 – CEASE TO ENERGIZE PERFORMANCE REQUIREMENT

Duke Energy requires cease to energize capability (not delivering power during steady-state or transient conditions) in accordance with the Standard. This can be an inbuilt function of the source or by disconnecting from the local EPS. The former is the preferred method.

A DER can be directed to cease to energize and trip by changing the Permit service setting to “disabled” as described in IEEE 1547 subsection 4.6.1.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Duke plans to review design document and equipment specification to verify an inbuilt function or identify the interconnection device that provides the cease-to-energize function. The existing inspection and commissioning process tests to verify the device meets the performance requirement.

SECTION 4.6 – CONTROL CAPABILITY REQUIREMENTS

Duke Energy will consider if there is a need to clarify any technical points for the final version of the guideline, but the expectation is that the capabilities in the following sections will be adopted as written.

Duke accepts the requirements in the following Standard sections as written:

4.6.1 Capability to disable permit service

4.6.2 Capability to limit active power

4.6.3 Execution of mode or parameter changes

This section of the Standard applies to all DER 250 kW or greater or DER with a local DER communication interface.

4.6.1 Capability to disable permit service

For UDER, Duke Energy is still considering implementing the permit service at the inverter or disconnecting at the local EPS. The expectation is that Standard compliant inverters will have this capability inbuilt.

Application to RDER has not been assessed. The expectation is that Standard compliant inverters will have this capability inbuilt, but Duke will not use it at this time. Future dispatch or emergency response functionality could possibly require this functionality for system reliability.

Duke policy requires a utility owned interconnection recloser for UDER ≥ 1 MW. In this case, the permit service is implemented by controlling the utility owned recloser. For DER ≥ 250 kW and < 1 MW, Duke allows the option of installing the small DG interface (automation controller) instead of the utility owned recloser. In this case, the permit service is implemented at the DER unit through the small DG interface.

Interoperability requirements: The present automation controller implementation includes a disable permit service control. The automation controller has the capability to provide a limit active power Analog Output sent via SCADA to control active power.

Verification and test requirements: Duke will review UL certification tests, type tests, design documents, and equipment specifications to identify the capability of the DER to meet this performance requirement.

4.6.2 Capability to limit active power

Active power limits can be static or dynamic. Static limits are fixed and is essentially part of the system impact study (SIS) process now because the maximum active power capacity (import or export) is often calculated during the SIS if the requested DER capacity is not possible without upgrades. The Standard defines the active power limit as a percentage of the Nameplate Active Power Rating. Duke interprets the

referenced rating as the Nameplate Active Power Rating at unity power factor. Consider too that the active power limit is manually set and Duke does not have the capabilities to adjust the limit based on time of day, load, or other variables. Adjusting the limit in real time is a dynamic limit.

Duke does not plan to implement real-time control during the initial implementation of the Standard. Significant technical studies are required to address concerns and consider remote real-time control of the active power limit. However, it is reasonable to make provision for this potential capability when designing the monitoring and control capabilities of the communication interface.

SECTION 4.7 – PRIORITIZATION OF DER RESPONSES

Duke accepts the requirements in the Standard and expects IEEE 1547-2018 compliant inverters to meet all prioritization requirements of this section of the Standard.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Duke plans to review UL certification testing, type tests results, and design documents to evaluate if a DER can meet this requirement.

SECTION 4.8 – ISOLATION DEVICE

Duke Energy accepts the requirements in the Standard and requires isolation devices per the Interconnection Agreement, Method of Service Guidelines, Requirements for Electric Service and Meter Installations (the White Book), and other interconnection documents. This is a current requirement that is unchanged by IEEE 1547-2018.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Existing site evaluation and inspection shall satisfy verification for this requirement.

SECTION 4.9 – INADVERTENT ENERGIZATION OF THE AREA EPS

Duke Energy requires DER not to energize the utility EPS when the utility EPS is de-energized, therefore accepts the Standard. When there is a planned and designed intentional island, per Section 8.2 Intentional Islanding, that configuration is not considered inadvertent.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Duke will only accept type-tested DER for small scale installations like RDER. For UDER, the existing inspection and commissioning process covers this requirement.

SECTION 4.10 – ENTER SERVICE

Duke Energy requires the DER to meet the requirements of all the following subsections:

4.10.2 Enter service criteria

4.10.3 Performance during entering service

4.10.4 Synchronization

Section 6.6 of the Standard is also encompassed by the requirements of Section 4.10.

4.10.2 Enter service criteria and 4.10.3 Performance during entering service

When entering service, the DER shall not energize the Area EPS until the following conditions are met at the RPA (these are the defaults in the Standard):

Enter service value	Parameter Label	Setting
Minimum Voltage	ES_V_LOW	≥ 0.917 p.u.
Maximum Voltage	ES_V_HIGH	≤ 1.05 p.u.
Minimum Frequency	ES_F_LOW	≥ 59.5 p.u.
Maximum Frequency	ES_F_HIGH	≤ 60.1 p.u.

Note: The parameter labels are based on the publicly available EPRI technical update document number 3002020201, Common File Format for Distributed Energy Resources Settings Exchange and Storage. EPRI, Palo Alto, CA: 2020.

The final UDER settings are still under evaluation. Duke will compare the final voltage trip and ride through settings for UDER with the Standard default settings. Assuming they are compatible, UDER will adopt the same Standard default values.

The DER shall not enter or return to service or ramp faster than the times stated below. The Standard allows an optional randomized time delay, but that option is not used and shall be Off. As noted in the standard, DER increasing active power steps greater than 20% of Nameplate Active Power rating shall require approval during the system interconnection study process.

Time Delay	Parameter Label	RDER setting (seconds)	UDER setting (seconds)
Enter Service Delay	ES_DELAY	300	300
Enter Service Ramp Period	ES_RAMP_RATE	300	300
Enter service randomized delay	ES_RANDOMIZED_DELAY	Off	Off

While the active power is ramping during the enter service period, the reactive power shall follow the configured mode and settings.

When connected in parallel with the Area EPS, energy storage DER (ESS) active power rate of change is dependent on the Configuration Active Power Rating per the table below:

Rate of Change Duration	Parameter Label	RDER setting (seconds)	UDER setting (seconds)
ESS \leq 1 MW	None	2	n/a
ESS > 1 MW	None	n/a	ESS MW range / (2 MW/sec)

The ESS MW range is the sum of the charge and discharge capability.

4.10.4 Synchronization

Duke Energy accepts the requirements in the Standard as written.

Interoperability requirements: No specific requirements for these sections.

Duke will evaluate if there is value in monitoring the enter service settings.

Verification and test requirements: For 4.10.2 and 4.10.3, Duke plans to verify the enter service and return to service settings in the field. The existing inspection and commissioning process tests to verify DER meets this requirement. For 4.10.4, Duke plans to review UL certification tests, type tests, and design documents to evaluate DER's synchronization capability meeting this requirement. The on-off test during commissioning will field verify DER's synchronization capability.

Implementation of this section requires publishing the final technical position and applying the interoperability functionality in the local interface.

SECTION 4.11 – INTERCONNECT INTEGRITY

Duke accepts the requirements in the Standard as written for the following subsections:

4.11.1 Protection from electromagnetic interference

4.11.2 Surge withstand performance

4.11.3 Paralleling device

Duke Energy does not have additional clarifications of these subsections.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: They standard type-testing is satisfactory for Duke.

SECTION 4.12 – INTEGRATION WITH AREA EPS GROUNDING

Duke accepts the requirements in the Standard and that the grounding scheme of the DER interconnection shall be coordinated with the ground fault protection of the Area EPS. Duke's system is multi-grounded and

the DER facilities and design must be compatible with the EPS. Each interconnection is reviewed for ground fault protection and for limiting the potential for creating over-voltages on the Area EPS.

Approved distribution connected utility scale DER transformer winding configurations are listed below. Therefore, configurations that are not listed are not approved. It is possible for an IC to submit another winding configuration, however the technical review will significantly delay evaluation of the IR.

Primary Winding Type (HV)	Secondary Winding Type (LV)	Zero Seq Maintained PCC to POC	Allowed for DER Interconnection	
			Inverter	Rotating
Wye-grounded	Wye-grounded	Yes, (w/4-wire LV)	Yes	Yes
Wye-grounded	Wye	No	Yes	No
Wye-grounded	Delta	No	No	Yes

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Duke plans to review the design document to evaluate if a DER can meet this requirement. The existing inspection and commissioning test process will cover this.

SECTION 5.2 – REACTIVE POWER CAPABILITY OF THE DER

Whether or not reactive power capability or voltage control is initially used for the DER, each DER shall submit the required reactive power capability information. This provides the information when it is most readily available and can be recorded in the event that it is needed later.

For categories related to reactive power capability and voltage regulation performance requirements, Duke Energy plans to require the following performance category:

Voltage and Reactive Power Category B

Category B requires a DER reactive power injection capability (lagging) of 44% of nameplate apparent power rating and 44% absorption capability (leading) of nameplate apparent power rating as defined in the Standard. The Standard adopted “44%” as the injection capability for 0.90 pf, but the percentage is actually slightly less, 43.6%. Duke will consider capabilities 43.6% and higher also meet the intent of the 44% requirement. As a good practice, Duke recommends that all facilities be designed to operate at these pf ratings should the situation arise over the life of the facility that the facility would want this capability.

Because the capability curve limit must be satisfied, the vector sum of the active and reactive powers must not exceed the apparent power capability². The reactive capability shall be provided on an inverter capability curve (P-Q graph) and shall be based at the rated voltage of the device (1 pu) and an ambient temperature of 35° C. The DER may choose to submit reactive capability data on a higher ambient temperature basis, however that data will still be applied as the 35° C capability (Duke cannot temperature adjust manufacturer data).

² See the EPRI document “Understanding Watt and Var Relationships in Smart Inverters”, 3002015102

Because operating points on the chart can be difficult to accurately determine, it is recommended that the DER provide the numerical data that defines critical points on the capability curve. Those points include the Nameplate and Configuration apparent, active, and reactive power ratings at the leading, lagging, and unity power factors.

Some facilities have operational, design, or other limitations that prevent utilization of the full reactive capability of the device(s). If that is the case, the DER shall specify any factors that limit or de-rate the output of the generator (e.g., collector system voltage limits, auxiliary voltage limits, net meter load voltage limits, current limits, and specific ambient temperature conditions). If no limitations are submitted, then Duke will consider that the facility has no reactive capability limitations. Duke recommends submittal of a facility capability curve that includes any limitations.

Supplemental Devices

If the DER includes supplemental devices, capability data must be provided for each device at rated voltage of the device and an ambient temperature of 35° C. Subject to the same conditions above, the DER may elect to submit data at a higher ambient temperature. For a dynamic device, capable of varying output magnitude, a capability curve must be provided with a brief written description and an acceptable power flow model of the device. If the supplemental device is static (i.e. a fixed capability), then a curve is not required, but the appropriate capability data must be provided and the type of device identified. Additionally, if there are multiple devices that form the complete DER, a composite capability curve that includes all sources, loads, and supplemental devices shall be provided.

Again, any limitations that prevent the full reactive capability of the device(s) to be utilized shall be specified and Duke recommends submittal of a facility capability curve that includes the limitations.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Duke plans to evaluate design documents and equipment specifications to determine reactive power capability. A field test may be required for DER to prove its reactive power capability. Duke expects to follow the commissioning tests requirements in IEEE 1547.1 to cover this topic.

SECTION 5.3 – VOLTAGE AND REACTIVE POWER CONTROL

Listed below are the Standard voltage and reactive power control options and the default status for Duke interconnections:

Control Mode	Default Status
Constant power factor (fixed pf)	On, 1.0 pf
Constant reactive power (fixed VAR)	Off
Voltage-reactive power (Volt-VAR)	Off
Active power-reactive power (Watt-VAR)	Off

Constant reactive power is not thought to be a particularly useful control mode. Constant power factor is the broad category of control that includes unity power factor, which can be useful, but is limited by

operating at a control point that is not based on feeder conditions. Duke is in the process of performing studies that will focus on voltage-reactive power mode and active power-reactive power mode for UDER. The Duke study will evaluate the application and consequences of these functions.

Part of the study effort is to determine if voltage regulation functions should be activated and how they should be configured. Before using these functions on a widespread basis, Duke Energy will evaluate the system impacts, identify any unanticipated effects, and then assess the control modes and settings. Because the impact of UDER reactive injection can be large, Duke limits the reactive capability that can be used for reactive power control to 0.95 power factor.

In North and South Carolina utility scale solar, UDER, is the majority of the solar capacity installed. Therefore, study efforts will focus on that type of facility. In due time, there should be some consideration for residential-scale inverters as well. The reactive control method and settings should consider existing operational requirements as well as mitigation of the high voltages that can occur with the addition of DER. No change can be made on one part of the system that does not affect another part. Therefore, the study will also consider the magnitude of influence the inverter has on voltage, reactive power flow impacts, remediation of impacts, and controlling the impact on the transmission system. Distribution Providers must comply with agreements and requirements of the transmission entities. As such, an evaluation of transmission impacts is important.

Significant technical studies are required to evaluate these functions and analyze the consequences. The studies began at the end of 2019 and will continue in 2021. This will continue to be an agenda item for the TSRG meetings will focus on the most useful control modes and settings that are applied locally in the inverter and are autonomous. The plan is to implement the Standard in phases. In this case, reactive power control will be fixed at unity power factor for the initial phase of implementation but may be implemented in a later phase.

Duke Energy has reviewed and considered all TSRG and submitted comments up to the date of this revision.

Interoperability requirements: There will be few, if any, requirements for fixed power factor DER. For other control modes, the interoperability requirements align with those in the EPRI document, Common File Format for Distributed Energy Resources Settings Exchange and Storage. EPRI, Palo Alto, CA: 2020. 3002020201.

Verification and test requirements: To verify DER compliance to this requirement, Duke will require evaluation of the volt-var settings and field settings verification. Due to complication of performing voltage tests in the field, Duke does not plan to require field commissioning test on this topic. Operational data may be required to evaluate the DER's performance meeting this requirement.

Additional analysis must be performed before finalizing the Verification and test requirements.

Implementation of this section requires publishing the final position, applying the interoperability functionality in the local interface, and integrating verification requirements into the overall commissioning test program.

SECTION 5.4 – VOLTAGE AND ACTIVE POWER CONTROL

The main requirement here involves subsection 5.4.2, Voltage-active power mode. The voltage-active power mode serves as a backup to voltage control. Should an unexpected high voltage condition arise, or the voltage cannot be controlled by the local reactive resources, the voltage-active power control will reduce the DER active power to assist with voltage control.

The default status for Voltage-active power control is Off.

The settings and specifications for voltage-active power control are included with the study discussed for Section 5.3. The plan is to implement the Standard in phases. In this case, volt-watt control will be Off for the initial phase of implementation but may be implemented in a later phase.

Interoperability requirements: The interoperability requirements align with those in the EPRI document, Common File Format for Distributed Energy Resources Settings Exchange and Storage. EPRI, Palo Alto, CA: 2020. 3002020201.

Even with autonomous operation there will be some requirements to communicate the mode and possibly other information. Because those requirements are not known at this time, Duke must perform additional analysis and interface testing for autonomous operation.

Duke has the initial I/O points for active power control. The SCADA interface required and operations and functional requirements are still to be determined.

In the future, there may be value in providing the necessary controls for remote utility control. That is second priority to autonomous operation, but that would require even more controls and monitoring. While the mode can be enabled/disabled with a Binary Output, separate Analog Outputs must be used to set the individual control setpoints.

Verification and test requirements: To verify DER compliance to this requirement, Duke will require evaluation of the volt-watt settings and field settings verification. Due to complication of performing voltage tests in the field, Duke does not plan to require field commissioning test on this topic. Operational data may be required to evaluate the DER's performance meeting this requirement.

Additional analysis must be performed before finalizing the Verification and test requirements.

Implementation of this section requires publishing the final position, applying the interoperability functionality in the local interface, and integrating verification requirements into the overall commissioning test program.

SECTION 6.2 – AREA EPS FAULTS AND OPEN PHASE CONDITIONS

Duke accepts the requirements in the Standard.

There is a possibility that these requirements could be impacted by an ongoing project involving the Protection and Transmission Planning groups. There is an enormous effort to model the system, perform iterative studies, perform the research, and evaluate protection settings. Duke Energy is working to determine the best DER recloser protection elements to optimize protection and ride-through performance and establish the abnormal operating performance Categories. Since the plan is to implement the Standard in phases, if anything does impact the current plan, then any changes could be considered for a later phase.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: The existing inspection and commissioning process covers the verification of this requirement. Duke plans to continue the practice and refine the process as necessary following the commissioning test requirements in IEEE 1547.1.

Implementation of this section requires publishing the final position, applying the interoperability functionality in the local interface.

SECTION 6.3 – AREA EPS RECLOSING COORDINATION

Duke accepts the requirements in the Standard as written.

There is a possibility that these requirements could be impacted by an ongoing project involving the Protection and Transmission Planning groups. There is an enormous effort to model the system, perform iterative studies, perform the research, and evaluate protection settings. Duke Energy is working to determine the best DER recloser protection elements to optimize protection and ride-through performance and establish the abnormal operating performance Categories. Since the plan is to implement the Standard in phases, if anything does impact the current plan, then any changes could be considered for a later phase.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: For large scale DER that is equipped with a Duke PCC recloser, such coordination will be considered under the Duke Energy DER Enterprise Standards. For other DER, Duke will follow the commissioning tests requirements in IEEE 1547.1.

Implementation of this section requires publishing the final position.

SECTION 6.4.1 – MANDATORY VOLTAGE TRIPPING REQUIREMENTS

Duke Energy has not determined the guidelines for this section.

This is a sub-task of an ongoing project involving the Protection and Transmission Planning groups. There is an enormous effort to model the system, perform iterative studies, perform the research, and evaluate protection settings. Duke Energy is working to determine the best DER recloser protection elements to

optimize protection and ride-through performance and establish the abnormal operating performance Categories. As placeholders, the present trip setpoints are added to the Guidelines.

Consensus was reached with Transmission System Planning and Operations for POI Recloser voltage and frequency settings and time delays that provide adequate ride-through for BES events. The team is still reviewing the impact to system protection with the proposed settings.

For new DER installations, the present voltage tripping setpoints are provided in the table below as placeholders and are not final.

Parameter	Voltage	Time
Undervoltage, UV Level 1	0.88 pu	10 cycles
Undervoltage, UV Level 2	0.5 pu	6 cycles
Overvoltage, OV Level 1	1.1 pu	10 cycles
Overvoltage, OV Level 2	1.2 pu	6 cycles

Interoperability requirements: To be determined.

It is expected that these values will be set and not changed remotely, however this position must be evaluated by Duke. Because these are critical protection setpoints, remote visibility of the setting would be a beneficial capability. Because requirements are not known at this time, Duke must perform additional analysis before establishing interoperability requirements. Note that this setting is incorporated in SUNSPEC MODBUS.

Verification and test requirements: The existing inspection and commissioning process covers the voltage trip settings field verification and Duke plans to continue that practice. Due to complication of performing abnormal voltage tests in the field, Duke plans to perform design evaluation and installation evaluation for the purpose of evaluating conformance of the DER, and currently does not plan to require field commissioning tests on this topic. Operational data collection after a DER or system event may be required to validate proper DER operation. IEEE 1547.1-2020 suggests signal injection test method may be considered if the DER has the provision for this method. Adjustment of the shall-trip settings may be made if verification of the mandatory trip function is required.

Implementation of this section requires publishing the final position and applying the interoperability functionality in the local interface.

SECTION 6.4.2 – VOLTAGE DISTURBANCE RIDE-THROUGH REQUIREMENTS

Duke Energy has not determined the guidelines for this section, but these requirements are being developed concurrently with Section 6.4.1 – Mandatory voltage tripping requirements.

See Section 1.4 for the abnormal performance category.

Interoperability requirements: To be determined.

It is expected that these values will be set and not changed remotely, however this position must be evaluated by Duke. Because these are critical protection setpoints, remote visibility of the setting would be a beneficial capability. Because requirements are not known at this time, Duke must perform additional analysis before establishing interoperability requirements. Note that this setting is incorporated in SUNSPEC MODBUS.

Verification and test requirements: To verify DER compliance, Duke will require evaluation of the DER ride-through settings and field setting verification. Due to complication of performing abnormal voltage tests in the field, Duke plans to perform design evaluation and installation evaluation for the purpose of evaluating conformance of the DER, and currently does not plan to require field commissioning tests on this topic. Operational data collection after a DER or system event may be required to validate proper DER operation. IEEE 1547.1-2020 suggests signal injection test method may be considered if the DER has the provision for this method. Adjustment of the shall-trip settings may be made if verification of the mandatory trip function is required.

Implementation of this section requires publishing the final position and applying the interoperability functionality in the local interface.

6.4.2.6 Dynamic voltage support

At least one Duke region requires dynamic reactive compensation for transmission connected DER. Application for the distribution system is still under evaluation.

SECTION 6.5.1 – MANDATORY FREQUENCY TRIPPING REQUIREMENTS

Duke Energy has not determined the guidelines for this section, but these requirements are being developed concurrently with Section 6.4.1 – Mandatory voltage tripping requirements. As placeholders, the present trip setpoints are added to the Guidelines.

For new DER installations, the present frequency tripping setpoints are provided in the table below.

Parameter	Frequency	Time
Underfrequency, UF	57 Hz	10 cycles

Overfrequency, OF	60.8 Hz	10 cycles
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Interoperability requirements: To be determined.

It is expected that these values will be set and not changed remotely, however this position must be evaluated by Duke. Because these are critical protection setpoints, remote visibility of the setting would be a beneficial capability. Because requirements are not known at this time, Duke must perform additional analysis before establishing interoperability requirements. Note that this setting is incorporated in SUNSPEC MODBUS.

Verification and test requirements: The existing inspection and commissioning process covers the frequency trip settings field verification and Duke plans to continue that practice. Due to complication of performing abnormal frequency tests in the field, Duke plans to perform design evaluation and installation evaluation for the purpose of evaluating conformance of the DER, and currently does not plan to require field commissioning tests on this topic. Operational data collection after a DER or system event may be required to validate proper DER operation. IEEE 1547.1-2020 suggests signal injection test method may be considered if the DER has the provision for this method. Adjustment of the shall-trip settings may be made if verification of the mandatory trip function is required.

Implementation of this section requires publishing the final position and applying the interoperability functionality in the local interface.

SECTION 6.5.2 – FREQUENCY DISTURBANCE RIDE-THROUGH REQUIREMENTS

For sections 6.5.2.1 through 6.5.2.4, concerning frequency ride-through:

Duke Energy has not determined the guidelines for this section, but these requirements are being developed concurrently with Section 6.4.1 – Mandatory voltage tripping requirements.

The Standard also includes several subsections related to frequency. Although Duke Energy considers these requirements mainly as functional specifications for the inverter, Duke Energy does have additional requirements or clarifications.

6.5.2.5 Rate of change of frequency (ROCOF)

Duke requires DER ride through a 3 Hz/s frequency excursion in accordance with abnormal operating performance Category III. DER tripping for ROCOF should be off, disabled, or above 3 Hz/s and within the ROCOF capability of the DER equipment. The DER shall certify that protective relay settings and DER controls are not designed or configured in such a way as to interfere with ROCOF performance.

This function, either at the inverter or the utility PCC recloser, is still under evaluation. Duke anticipates adopting the 1547 requirements if that is supported by the ongoing project.

6.5.2.6 Voltage phase angle changes ride-through

The UL 1741 SB certification shall be considered sufficient for individual inverter based DER devices meeting ride through requirements for this function. The DER shall certify that protective relay settings & controller settings of the completed DER facility do not intentionally trip for the voltage phase angle changes specified by the Standard.

This function, either at the inverter or the utility PCC recloser, is still under evaluation as part of an ongoing project involving the Protection and Transmission Planning groups. Duke anticipates adopting the requirements above if that is supported by the ongoing project.

6.5.2.7 Frequency-droop (frequency-power) capability

Duke accepts the default operation conditions and settings in the Standard as written:

Operation for low-frequency conditions	Mandatory, On
Operation for high-frequency conditions	Mandatory, On

Parameter	Setting
dbOF, dbUF (Hz)	0.036
kOF, kUF	0.05
T-response (small-signal) (s)	5

At this time, a frequency deadband of 36 mHz and a droop of 5% are considered acceptable for inverter and non-inverter sources. As the mix of generation sources transition over time, it may be necessary to transition to a lower values in the future to maintain EPS reliability.

This function is still under evaluation as part of an ongoing project involving the Protection and Transmission Planning groups. Per Standard table 24, a specification of the droop, deadband, and associated parameters is required for Category II and III.

6.5.2.8 Inertial response

Duke Energy has not determined the guidelines for this subsection. This capability is not required by the Standard but is permitted.

Interoperability requirements: To be determined.

It is expected that these values for Section 6.5.2 will be set and not changed remotely, however this position must be evaluated by Duke. Because these are critical protection setpoints, remote visibility of the setting would be a beneficial capability. Because requirements are not known at this time, Duke must perform additional analysis before establishing interoperability requirements. Note that this setting is incorporated in SUNSPEC MODBUS.

Verification and test requirements: To verify DER compliance, Duke will require evaluation of the DER ride-through settings and field setting verification. Due to complication of performing abnormal frequency tests in the field, Duke plans to perform design evaluation and installation evaluation for the purpose of evaluating conformance of the DER, and currently does not plan to require field commissioning tests on this topic. Operational data collection after a DER or system event may be required to validate proper DER

operation. IEEE 1547.1-2020 suggests signal injection test method may be considered if the DER has the provision for this method. Adjustment of the shall-trip settings may be made if verification of the mandatory trip function is required. Also note for the individual functions, that Duke reserves the right to verify that protective relay settings & controller settings do not interfere with or prevent proper performance the various ride-through requirements.

Implementation of this section requires publishing the final position and applying the interoperability functionality in the local interface.

SECTION 7.2.2 – RAPID VOLTAGE CHANGES

Duke has an existing process that is part of the system impact study to assess the risk of Rapid Voltage Changes (RVC) and require mitigation if necessary. Duke considers that the existing RVC criteria, stated below, is consistent with the Standard.

Rapid Voltage Change analysis is performed for all facilities 1 MW capacity and larger using appropriate modeling techniques (e.g. PSCAD). The study evaluates the effect of transformer energization, with the voltage change evaluated anywhere on the circuit to assure a change no greater than 3%. The study will consider combinations of residual flux and closing angle that cause a large voltage dip. When the RVC limit cannot be met without some form of mitigation, the method of mitigation must also limit inrush such that the RVC is no greater than 3%.

A Controlled Switching Device (CSD) shall also limit the transformer inrush voltage change to 3%. For CSDs that must learn or be calibrated in order to provide maximum inrush current reduction, a 6% RVC limit is temporarily applicable only during that limited calibration time (the higher inrush is only expected for the minimum amount of closes needed to calibrate the CSD). The higher limit only applies to special situations such as CSD commissioning, or following breaker maintenance or replacement, or the CSD undergoes some upgrade or repair and does not apply to normal operation conditions.

Interoperability requirements: A power quality meter is currently required for DER of 1 MW or greater and no additional requirements are proposed for the revised Standard.

Verification and test requirements: The installation verification is currently included in the scope of Duke's interconnection inspection process. Duke will develop a test procedure and criteria to evaluate the performance of an RVC mitigation solution as part of the commissioning tests.

SECTION 7.2.3 – FLICKER

Duke Energy accepts the requirements in the Standard. Note that Duke also applies IEEE 1453 recommended practices.

Interoperability requirements: A power quality meter is currently required for DER of 1 MW or greater and no additional requirements are proposed.

Verification and test requirements: Duke plans to review design document and equipment specification to evaluate the potential flicker cause DER. A power quality meter is required for the field tests. Duke plans to follow the commissioning tests requirements in IEEE 1547.1. Operational data collection after a DER or system event may be required to validate proper DER operation.

SECTION 7.3 – LIMITATION OF CURRENT DISTORTION

Duke Energy accepts the requirements in the Standard. The industry has found that the inverter designs are reaching and exceeding the harmonic monitoring capabilities of existing measurement devices. Therefore, Duke Energy requires the DER owner to mitigate harmonics greater than the 50th order to no greater than 0.3% of the fundamental DER rated current at the RPA. In addition, any Adverse Operating Effects must be addressed as noted in the DER Interconnection Agreement. Harmonic limits shall be aggregated and applied during the DER hours of operation, not just at peak or rated output.

Interoperability requirements: No specific requirements for this section. Installation of a power quality meter is already part of the required design for DER 1 MW and greater.

Verification and test requirements: Duke plans to follow the commissioning tests requirements in IEEE 1547.1.

SECTION 7.4.1 – LIMITATION OF OVERVOLTAGE OVER ONE FUNDAMENTAL FREQUENCY PERIOD

Duke Energy accepts the requirements as written in the Standard.

Part of 7.4.1 is based on the inverter design and operation and part is based on the specific design of the interconnection and the Area EPS itself. The ability of the inverter to detect and limit overvoltage will be verified by UL certification testing. However, the DER facility must still be analyzed during system impact study to verify the impact of the combined inverter and Area EPS is below the limits of the Standard. The limits defined in parts a) and b) must be verified by power system study. In addition, any Adverse Operating Effects must be addressed as noted in the DER Interconnection Agreement.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Duke plans to rely on UL certification testing, review type tests results, and examine design documents to evaluate the potential overvoltage contribution from DER. Duke plans to develop a test procedure and criteria for transient overvoltage during the commissioning test. A power quality meter is required for the field tests. Duke plans to follow the commissioning tests requirements in IEEE 1547.1.

SECTION 7.4.2 – LIMITATION OF CUMULATIVE INSTANTANEOUS OVERVOLTAGE

More industry experience or analysis could be essential to address this issue. Duke does not plan to implement this section until IEEE 1547.1 is revised and UL 1741 certification tests include this verification. At that time, Duke expects to accept the requirements as written in the Standard.

Interoperability requirements: No specific requirements for this section.

Verification and test requirements: Duke plans to review type tests results and design documents to evaluate the potential overvoltage contribution from DER. Duke plans to develop a test procedure and criteria for transient overvoltage during the commissioning test. A power quality meter is required for the field tests. Duke plans to follow the commissioning tests requirements in IEEE 1547.1.

SECTION 8.1 – UNINTENTIONAL ISLANDING

Duke Energy has not determined the guidelines for this section.

This is a sub-task of an ongoing project involving the Protection and Transmission Planning groups. There is an enormous effort to model the system, perform iterative studies, perform the research, and evaluate protection settings. Duke Energy is working to determine the best DER recloser protection elements to

optimize protection and ride-through performance and establish the abnormal operating performance Categories. As placeholders, the expected requirement is noted below.

Duke accepts the requirements in the following Standard sections as written:

8.1.1 General

8.1.2 Conditional extended clearing time

8.1.3 Area EPS with automatic reclosing

If there is the option to activate or deactivate the anti-islanding function, it shall be activated or the status On.

The standard clearing time for an unintentional island is 2 seconds. The DER shall identify and provide the method of islanding detection* used for all DERs above 250 kW.

Interoperability requirements: No control points are expected. Need to determine if any monitoring is necessary.

Verification and test requirements: To be determined.

* Such as one of the six groups listed in section 2.3 Generic Island Detection Groups and Response Models of Inverter-Onboard Islanding Detection Assessment: Final Project Report. EPRI, Palo Alto, CA:2020. 3002014051.

SECTION 10.1, 10.7, 10.8, 10.9 – GENERAL INTEROPERABILITY AND PROTOCOL REQUIREMENTS

These sections of the Standard relate more directly to the hardware requirements of the DER interface. Duke Energy adopts these requirements of these sections as written in the Standard.

Duke requires an interconnection recloser interface for DER rated ≥ 1 MW and the default protocol is DNP3. If mutually agreed upon by the Area EPS operator and DER operator, Modbus may be used as the only exception to DNP3.

For DER ≥ 250 kW and < 1 MW, Duke requires an automation controller interface and with Modbus protocol.

In all applications, there shall be one point of interface between a single Duke automation controller and a single DER automation controller or a single DER source (e.g., one individual inverter). Verification and test requirements: Operation of the hardware, point mapping, information exchange, and communication of data will be part of the commissioning tests requirements.

SECTION 10.2, 10.3, 10.4, 10.5, 10.6 – DATA, MONITORING, AND CONTROL INFORMATION

These sections of the Standard contain both general and specific data, monitoring, and control information. Sections 10.3 and 10.4 primarily contain general information such as DER ratings and configuration characteristic data that does not change often, if ever. This is the basic information provided by each DER interface. On the other hand, 10.5 and 10.6 provide real-time monitoring, control, and status information that is dependent upon the specific functions in use. Therefore, the specific parameters in the interface point map will be based on the Standard and the DER functions that are enabled. Each section of the Guidelines contains an “Interoperability requirements” subsection that defines the associated data, monitoring, and control requirements in addition to any Standard requirements.

Verification and test requirements: Operation of the hardware, point mapping, information exchange, and communication of data will be part of the commissioning tests requirements.

Additional discussion about ratings and limits:

Sections 10.3 and 10.4 address the two broad types of information available through the local DER communication interface. Section 10.3 specifies various DER ratings and 10.4 specifies configuration settings, which are often more clearly thought of as limits. While there is some commonality, the intent of the nameplate and configuration terms are different.

The following terms are listed in decreasing order of magnitude. The value of each parameter in the list is greater than or equal to the value of the parameter below it:

- Nameplate Apparent Power Maximum Rating
- Configuration Apparent Power Maximum Rating
- Nameplate Active Power Rating (unity power factor)
- Configuration Active Power Rating (unity power factor)

The list above does not address all the terms in the table. Such a specification is not necessary of every term, but helpful to clarify for some. Duke will consider addressing other terms as needed. Consequently, operational limits and settings, such as the Active Power Limit, cannot be greater than the ratings (not applicable to abnormal or protection settings).

Ratings are considered a permanent characteristic of a device or a system and are characterized by:

- Rating is the full capacity of the equipment or system.
 - The rating is the most capacity the system is designed to provide
- Rating represents a continuous capacity. Operation at the Rating can continue for indefinitely long periods without exceeding design limits and without reducing the life or maintenance interval.
 - Also, there can be short-term ratings that are time limited. Operation within the parameter and time limit does not exceed design limits or negligibly reduce the life or maintenance interval.
- Rating is the base upon which other model, analysis, and inverter parameters are referenced.

- Ratings are a common way to identify and classify devices.

Limits are not included in these sections of the Standard. However, their relationship to and differences from ratings are important. Limits are adjustable, provide boundaries not to be exceeded, and are less than or equal to ratings. Limits are characterized by:

- Limits impose boundaries on device operation, often to restrict operation within ratings.
- Limits can be established or defined by contractual, system design, or physical equipment restrictions.
- Limits are set for a controlled variable and must not be exceeded (e.g. boundary condition).
- Limits are often stated as a percent of the rating (therefore necessitating a fixed rating value).

The Nameplate Active Power Rating is an important design parameter for the DER, but also as an important base parameter for modeling. The same for Nameplate Apparent Power Maximum Rating, for some equipment or models, parameters may be specified in terms of percent of Nameplate Apparent Power or Nameplate Active Power Rating. In cases where operation to the full Nameplate Active Power Rating is not acceptable for the application, then the Configuration Active Power Rating can be set to establish a lower rating. While the minimum of these two values sets the overall rating, it can be important to distinguish between these when it comes to equipment specifications and modeling.

UNADDRESSED REQUIREMENTS OF IEEE 1547-2018

The remaining IEEE 1547-2018 clauses and sections not discussed above will be undertaken following the completion of the higher priority topics. Concerning the clauses and sections not addressed in this document, Duke Energy expects that the DER shall conform to the Standard itself as written.

APPENDIX – IEEE 1547-2018 BENCHMARKING

Duke Energy requested that Navigant Consulting, Inc. to facilitate the stakeholder discussion at the January 2020 TSRG meeting and to perform benchmarking. The following table was developed by Navigant Consulting, Inc.

TABLE B.1. BENCHMARKING OF IEEE 1547-2018 FUNCTIONALITIES IMPLEMENTATION

IEEE 1547 Section	Topic	Duke Order (pre-stakeholder)	Minnesota/ Colorado (Xcel Energy)	Ameren / MISO
6.4.2	Voltage disturbance ride-through requirements	1	1	1
5.3	Voltage and reactive power control	1	1	1
6.5.2	Frequency disturbance ride-through requirements	2	1	1
6.4.1	Mandatory voltage tripping requirements (OV/UV)	1	1	2
5.4.2	Voltage-active power control	1	1	2
6.5.2.7	Frequency-droop (frequency-power) capability	2	1	2
6.5.1	Mandatory frequency tripping requirements (OF/UF)	2	1	2
5.2	Reactive power capability of the DER	1	1	
4.5	Cease to energize performance requirement [Reliability]	3	2	
4.6.1	Capability to disable permit service	3	2	
4.6.2	Capability to limit active power	3	2	
4.10.2	Enter service criteria	4	3	2
7.2.2	Power Quality, Rapid voltage change (RVC)	1	3	
4.10.3	Performance during entering service	4	3	
4.10.4	Synchronization	4	3	
4.2	Reference points of applicability (RPA) [Interconnection]	4	3	
6.5.2.5	Rate of change of frequency (ROCOF)	4	4	1
4.10	Enter service [Reliability] // 6.6 Return to service after trip	4	4	2
6.4.2.6	Dynamic voltage support		4	2
4.3	Applicable voltages [Manufacturer]	4	4	
4.11.3	Paralleling device	4	4	
6.2	Area EPS faults and open phase conditions [Reliability]		4	
6.3	Area EPS reclosing coordination [Reliability]		4	

IEEE 1547 Section	Topic	Duke Order (pre-stakeholder)	Minnesota/ Colorado (Xcel Energy)	Ameren / MISO
10.2	Monitoring, control, and information exchange requirements		4	
10.5	Monitoring information		4	
10.1	Interoperability requirements		4	
10.3	Nameplate Information		4	
10.4	Configuration information		4	
10.6	Management information		4	
10.7	Communication protocol requirements		4	
10.8	Communication performance requirements		4	
10.9	Cyber security requirements		4	
11	Test and verification		4	
8.2	Intentional islanding		4	
11.4	Fault current characterization		4	
9	Secondary network		4	
4.6.3	Execution of mode or parameter changes [Manufacturer]		4	
6.5.2.6	Voltage phase angle changes ride-through	2		1
6.4.2.5	Ride-through of consecutive voltage disturbances			1
7.2.3	Power Quality, Flicker	1		
7.4	Limitation of overvoltage contribution	1		
6.5.2.8	Inertial response			
7.3	Limitation of current distortion			
8.1	Unintentional islanding			
4.7	Prioritization of DER responses			
4.8	Isolation device [Interconnection]			
4.11.1	Protection from electromagnetic interference			
4.11.2	Surge withstand performance			
4.12	Integration with Area EPS grounding [Reliability]			
4.13	Exemptions for Emergency Systems and Standby DER			
4.9	Inadvertent energization of the Area EPS [Interconnection]			

ATTACHMENT F

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DER Commissioning Update

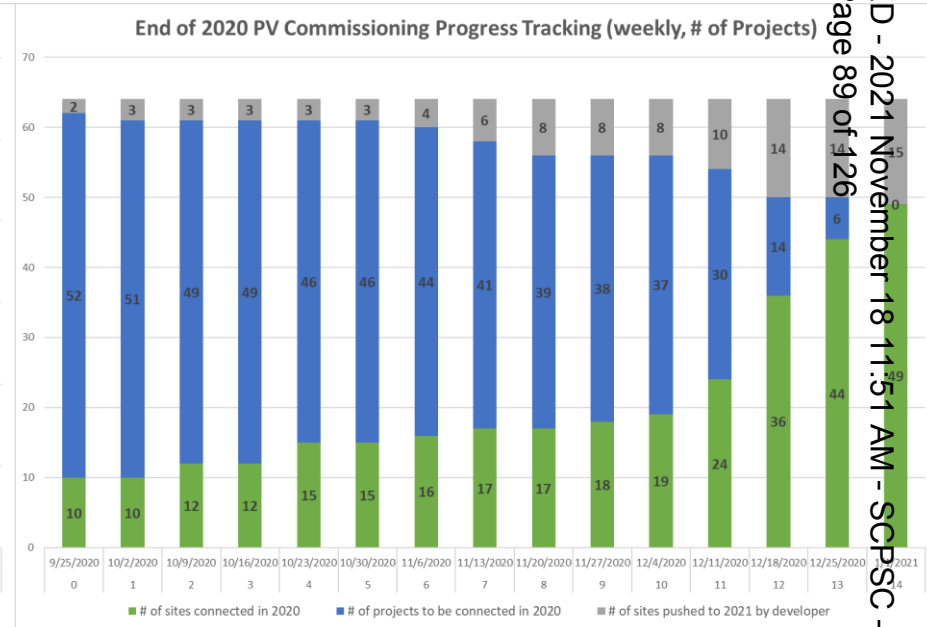
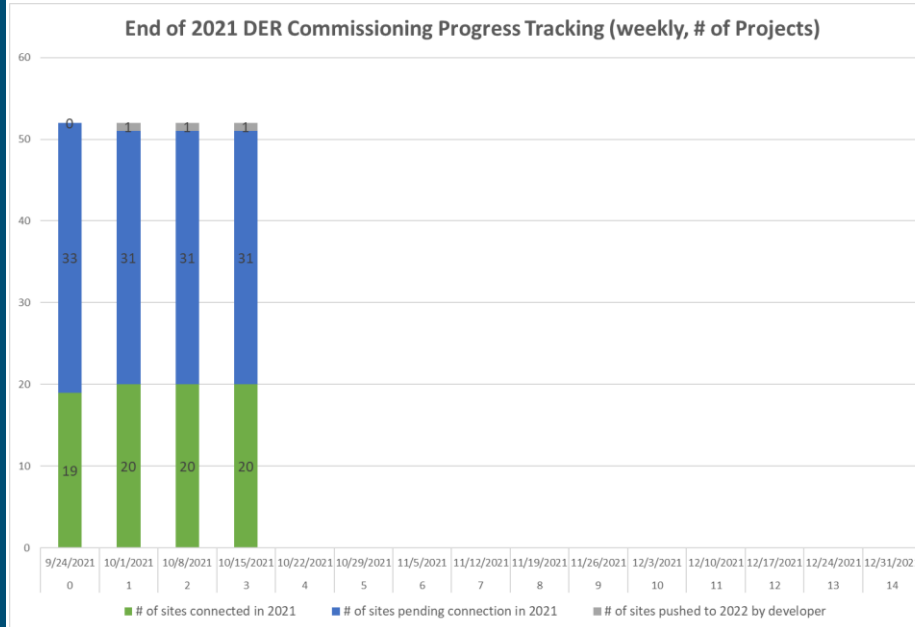
Kevin Chen 10/20/2021



- 4th Quarter Solar Commissioning Update
- Inspection of Uninspected Facilities
- IEEE Std 1547-2018 Education and Credentialing Program
- Transmission Connected IBR Inspection and Commissioning
- Q&A, open discussion

- The updated commissioning process and conditional commissioning process documents have been shared with customers in August.
- We had 1-on-1 meeting with each developer that has active projects in Q4.
- Before 10/15/2021, Duke and AE reached out to every developer with a list of project status and schedule.
- All sites that are pending initial inspection have been scheduled. Every project has inspection time slot on the calendar.
- For the projects participating the smart inverter pilot, the DER functional settings verification and the commissioning test will be modified to include the verification of specified grid support functions.

- As of 10/20/2021, there are 31 sites to be connected before the end of 2021.
 - The conditional commissioning process started from 10/1/2021.
 - It is critical for the developer to keep the scheduled inspection dates.



- 4th Quarter Solar Commissioning Update
- Inspection of Uninspected Facilities
- IEEE Std 1547-2018 Education and Credentialing Program
- Transmission Connected IBR Inspection and Commissioning
- Q&A, open discussion

- Duke believes the inspection at Uninspected Facilities is necessary and appropriate to ensure compliance with the terms of the NCIP as well as to ensure the Companies (DEC and DEP) “are in a position to ensure the safety and integrity of the grid.”
- Duke also recognizes that Interconnection Customers owning and operating Uninspected Facilities have an interest in ensuring the safety and integrity of the grid, consistent with the requirements of the 2019 NCIP Order and the Inspection Provisions.
- The self-inspection process has been drafted and all previously developed self-inspection documents are posted on the TSRG website.
- Interconnection Customers expressed their concerns in Duke requiring and implementing inspection of Uninspected Facilities.

- Duke worked in good faith to develop and execute a Memorandum of Agreement (the “MOA” with Strata Interconnection Customers.
- The MOA memorializes a framework for Strata to develop a “self-administered compliance program” that commits Strata’s Uninspected Facilities to adhere to the Inspection Provisions.
- Duke believes the MOA framework comports with good utility practice and can serve as a path forward for other owners of Uninspected Facilities to implement post-commissioning inspections and take action to ensure the safety and reliability of the grid.
- NCUC Order on 10/8/2021 clarifies that the 2019 revisions to NCIP Section 6.5 apply to all Generating Facilities, regardless of the date of their Interconnection Agreements.

NCUC Order on 10/8/2021 Clarifying Generator Interconnection Standards, Requesting Comments, and Requiring Filing of Remediation Information.

(<https://starw1.ncuc.net/NCUC/ViewFile.aspx?id=c1761ece-ee25-4b30-8c96-01ae88fd394c>)

- *...All other Interconnection Customers with Uninspected Facilities shall work with Duke develop similar self-inspection programs, memorialized in memoranda of agreement.*
- *All Interconnection Customers that own Uninspected Facilities must enter into a self-inspection agreement with Duke by **no later than February 1, 2022**, and must complete self-inspections of the Uninspected Facilities within three years from the date of execution of the agreement with Duke.*
- *Duke shall file a report with the Commission by February 23, 2022, as to the status of the self-inspection agreements entered into and any remaining Uninspected Facilities that are not covered by an agreement.*
- *...The Commission shall take additional action, as necessary, with respect to the inspection of the Uninspected Facilities should Interconnection Customers and Duke not be able to reach agreement on the timely self-inspection of the Uninspected Facilities.*

- Interconnection Customers with Uninspected Facilities have the following options:
 1. Work with Duke to develop a self-administered compliance program, memorialized in memoranda of agreement, to comply with the requirements of Sections 6.5.2 and 6.5.3.
 - Duke will work with the customer to ensure the self-administered compliance program would cover the scope of the developed **Self-inspection Process** and **Self-inspection Manual**.
 2. For the facility not covered by an agreement, Duke will dispatch resources to inspect the facility and invoice the customer for the cost of inspection.
- Duke wants to require the Interconnection Customers with Uninspected Facilities to decide one of above options by **December 1st, 2021** in order to allow enough time for Duke and Customers to prepare for the MOA.

- Interconnection facility as-built evaluation
 - *Strata Interconnection Customers* (“Strata IC” in rest of the slide) *will perform a one-time effort to validate the single-line diagram of all Legacy Facilities.*
- Interconnection Equipment Settings
 - *Strata IC will perform initial inspection of applicable inverter and interconnection device settings for all Legacy Facilities...*
 - *Strata IC will follow the **DER Functional Settings Guidance Document** that has been developed as part of the MOA.*
- Access to Duke Energy POI
 - *Strata IC will provide one-time photographic documentation to Duke that right-of-way access for Duke POI facilities is properly maintained in a manner consistent with Duke standards and requirements.*
 - *As part of Strata IC Self-Administered Compliance Program, Strata IC will include information about preventive maintenance for ROW access...*

- MV Construction Inspection of Uninspected Facilities
 - *Strata Interconnection Customers will ensure adherence to Duke's comprehensive construction specification in its Outside-The-Fence Facilities inspections.*
- *Periodic Inspections under Self-Administered Compliance Program*
 - *Periodic Inspection shall be completed after the Initial Inspection for the Outside-The-Fence Facilities at least once every 5 years... continue to meet Duke construction specification...*
 - *Strata IC will adhere to DER Function Settings Compliance Document in completing Periodic Inspections...*
- Cease-to-Energize Test
 - *Strata IC will perform a "cease-to-energize test" as part of the scope of its Periodic Inspection of Outside-The-Fence Facilities.*

The Duke-Strata MOA can be found in the reply comments filed to NCUC from Duke ([link](#)) and Strata ([link](#)), respectively.

- 4th Quarter Solar Commissioning Update
- Inspection of Uninspected Facilities
- IEEE Std 1547-2018 Education and Credentialing Program
- Transmission Connected IBR Inspection and Commissioning
- Q&A, open discussion

Goal of the IEEE 1547 Credentialing Program

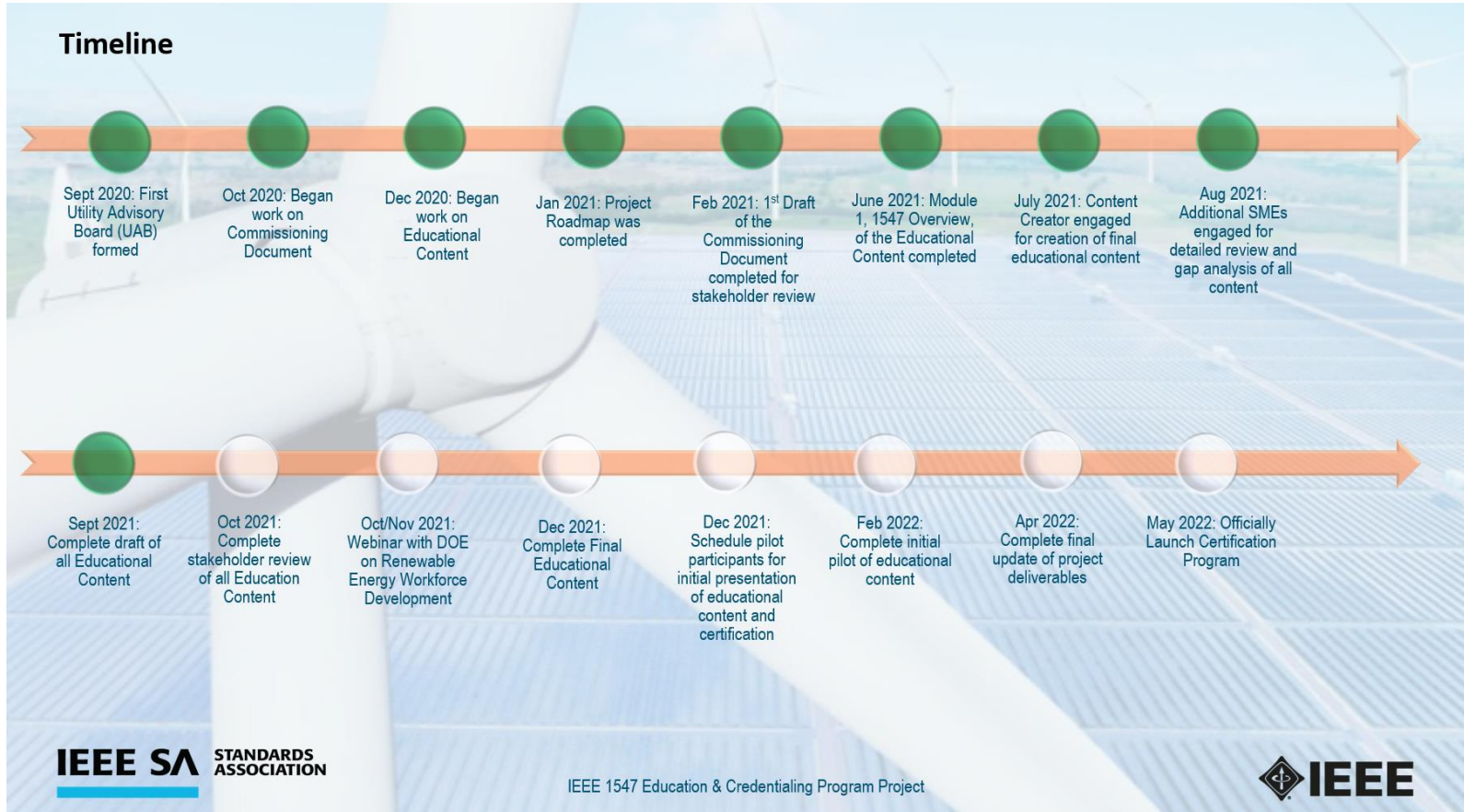
Create a credentialing program that will train and certify individuals who can verify any installed DER Interconnection (e.g., Residential, Utility-Scale, Micro-grid, etc.) for its compliance with the IEEE 1547™-2018 standard and local jurisdictional requirements.

Strong Utility Support

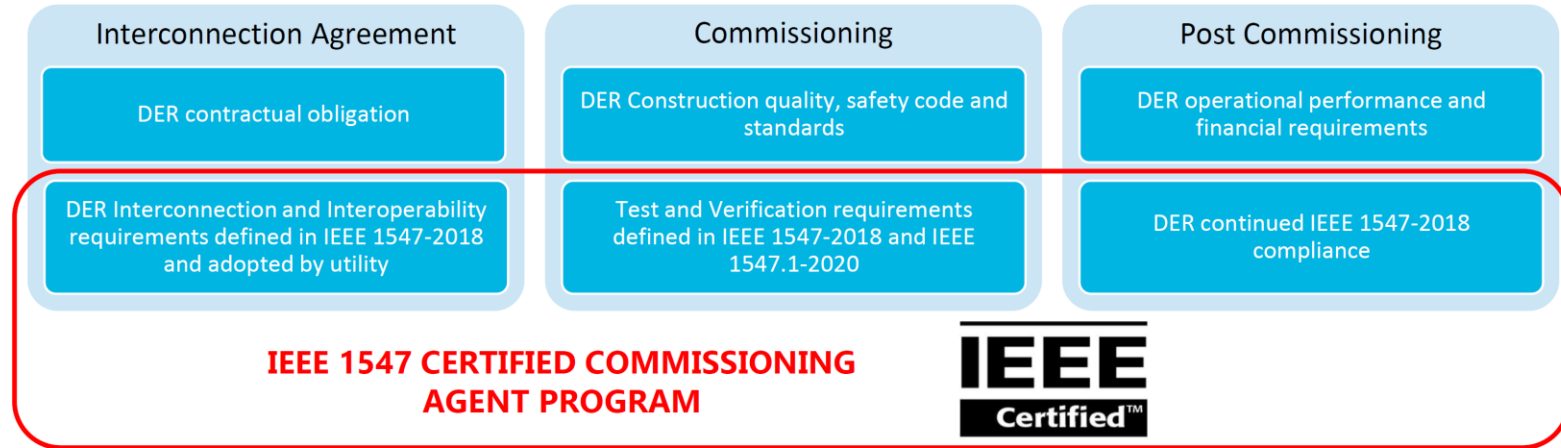
This effort is in collaboration with industry leading utilities who have committed time and resources to addressing the industry gap in IEEE 1547™ understanding and proper DER interconnection in the field.



ATTACHMENT F



ADDRESSING DUKE ENERGY'S NEEDS

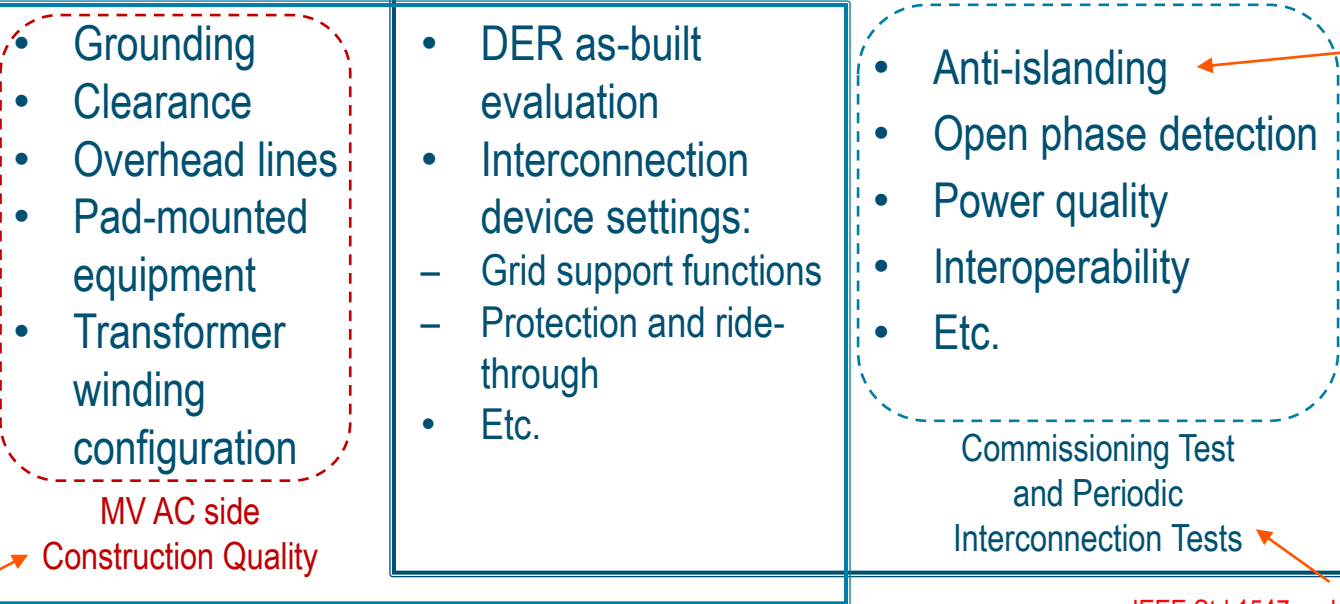


- Streamline and Standardize the 1547 compliance assessment for Residential PV and small-scale PV Projects. No such process at Duke currently.
- Supplement and enhance the existing utility-scale DER commissioning process at Duke.

Utility-scale DER Inspection and IEEE 1547 Conformity Assessment

ATTACHMENT F

IEEE Std 1547 ← NCIP 6.17 and Attachment 4



Scope of Inspection

Inspection + Commissioning Test + Periodic Inspection and Test

IEEE 1547 Conformity Assessment DOES NOT cover MV construction quality inspection.

NCIP 6.5.2 and 6.5.3
IA 1.5.4

IEEE Std 1547 and IEEE Std 1547.1

- Duke shares the same thoughts as IEEE-SA and other UAB members that this program is an important step in addressing the industry gap in IEEE 1547 understanding and proper DER interconnection in the field.
- The timeline of this program aligns with the timing of IEEE 1547-2018 compliant inverters being available and growing adoption of the IEEE 1547-2018 and IEEE 1547.1-2020 across the states.
- Developing local resources through the standardized training and certificate program will facilitate the implementation of relevant policy and requirements.

- 4th Quarter Solar Commissioning Update
- Inspection of Uninspected Facilities
- IEEE Std 1547-2018 Education and Credentialing Program
- Transmission Connected IBR Inspection and Commissioning
- Q&A, open discussion

Transmission Connected IBR Inspection and Commissioning

ATTACHMENT E

- Duke is developing an inspection and commissioning process for transmission-connected IBR facilities to ensure the facilities meet the interconnection reliability requirements.
- NERC has published multiple reports related to the reduction of solar PV power output following BPS fault.
 1. Blue Cut Fire Disturbance, 8/16/2016
 2. Canyon 2 Fire Disturbance, 10/9/2017
 3. Angeles Forest Disturbance, 4/20/2018
 4. Palmdale Roost Disturbance, 5/11/2018
 5. San Fernando Disturbance, 7/7/2020
 6. Odessa Disturbance, 5/9/2021 and 6/26/2021
- The pilot inspection scope includes:
 - 1) Verify the equipment at the constructed facility agrees with the Duke Energy approved documentation
 - 2) Verify equipment settings agree with Interconnection Agreement (IA) and other Duke Energy requirements
- Findings from a recent pilot inspection led to recommendations to both Duke and customer.
- Once Duke has drafted a process, it will be presented to and reviewed by the TSRG.

- 4th Quarter Solar Commissioning Update
- Inspection of Uninspected Facilities
- IEEE Std 1547-2018 Education and Credentialing Program
- Transmission Connected IBR Inspection and Commissioning
- Q&A, open discussion

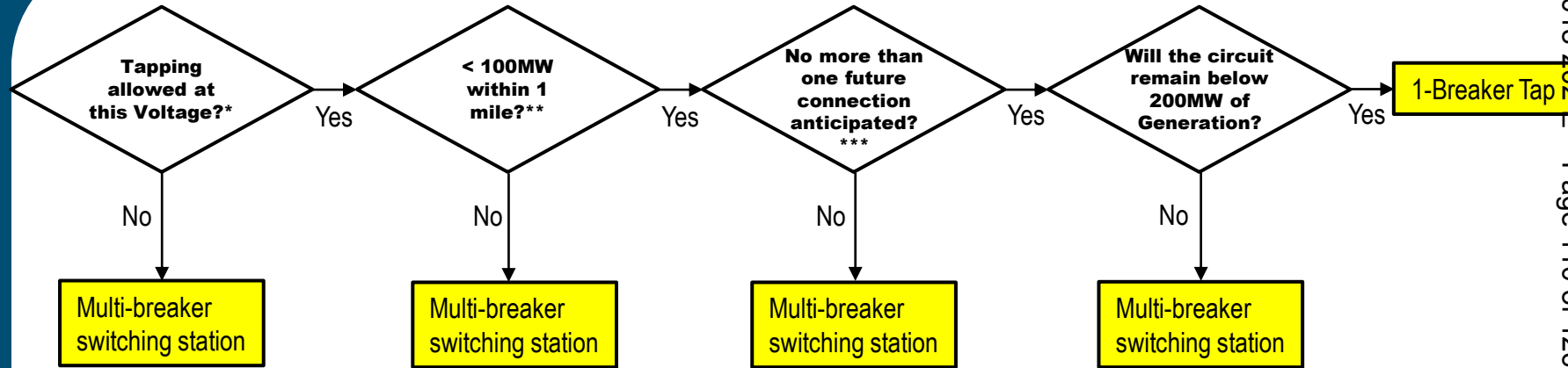
ATTACHMENT F



Substation Configuration Guideline for Transmission Inverter-Based Resource (IBR) Interconnections



- This guideline is a formalized documentation of Duke Energy's enterprise approach for Transmission Inverter-Based Resource (IBR) Interconnections.
- The purpose of the guideline is to aide in Duke Energy's decision-making process for the interconnection of Transmission connected inverter-based generation not to exceed 75MW at Greenfield Substation.
- Duke Energy Transmission Planning, Transmission Engineering, Transmission Operations will use the guideline as a tool in determining the preferred configuration of Greenfield Substations to accommodate proposed interconnections.
- If interconnection at a particular voltage is deemed acceptable based on the generating project's characteristics (i.e., size), the following flowchart provides general guidance about what the interconnection to the transmission system may look like.



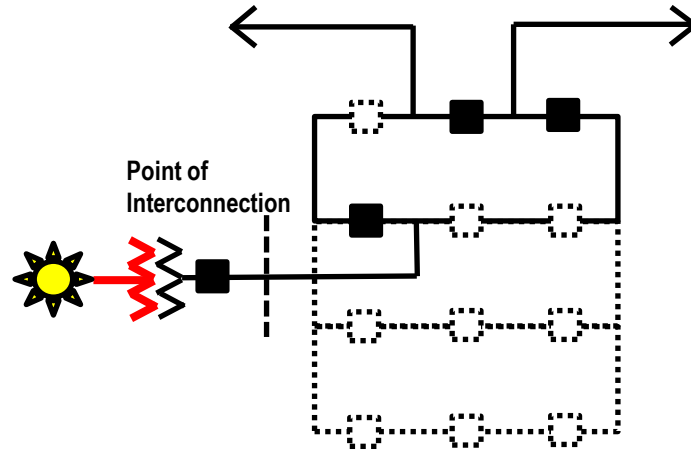
Duke Energy reserves the right to modify this flowchart as necessary with engineering judgment.

* Tapping allowed as follows: DEC 115 kV and below, DEP 230 kV and below, DEF 115 kV and below, DEMW 138 kV and below.

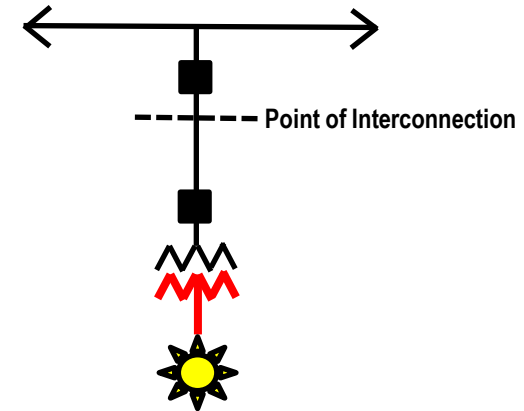
** Total site capacity within 1 mile.

*** Future connections can include potential generator interconnections, load delivery points, or additional transmission lines in the 10-year planning horizon, within 3 miles of the proposed Point of Interconnection (POI).

Multi-Breaker *

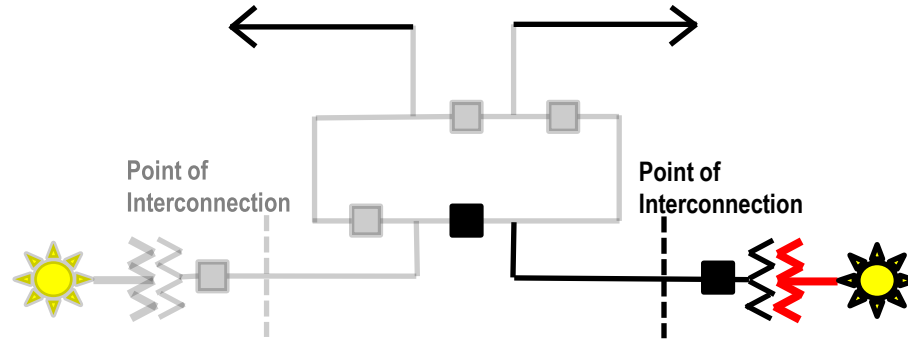


1-Breaker Tap

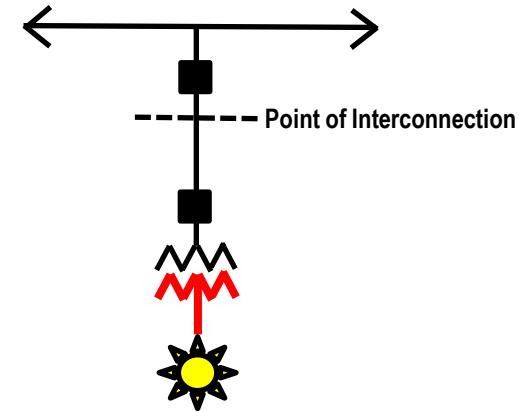


*Figure depicted is DEF ring bus, ultimate breaker & 1/2

Multi-Breaker *



1-Breaker Tap



*Figure depicted is ring bus, new breaker on the ring is a network facility.

- This guideline is a formalized documentation of Duke Energy's enterprise approach for Transmission Inverter-Based Resource (IBR) Interconnections.
- Purpose is to increase transparency.
- This is **not** a change to current processes and procedures.
- Stored on OASIS under the Generator Interconnections Information folder.

- DEP
- DEC
- DEF

AUTHORIZED COPY

Substation Configuration Guideline for Transmission Inverter Based Interconnections

Document ID: GDUF-0228-1988-00004

Revision: 001

Author: Duke Energy - Transmission Planning, Construction Engineering, Transmission Operations

Subject: Substation, Multi-breaker Switching Station, Power Management

Project Name:

Interconnection Queue Number of Application:

Forming Project ID:

Number of Applications:

Checklist Completed by:

Date:

PURPOSE
The purpose of this checklist is to aid in Duke Energy's decision-making process for the interconnection of Transmission connected inverter-based generation not to exceed 250MW at a Greenfield Substation. Duke Energy Transmission Planning, Transmission Engineering, Transmission Operations will use this guideline as a tool in determining the preferred configuration of Greenfield Substations to accommodate proposed interconnections.

CHECKLIST
Use the following checklist to guide the decision in selecting the preferred configuration for the new Transmission Substation site.

Question Number	Yes	No	Description
1			Is tapping allowed at this Voltage? *
2			Is the total site capacity, within 1 mile, less than 100 MW? **
3			Is there no more than one additional future connection anticipated? ***
4			IBR generation on the circuit remain below 250 MW? ****

Duke Energy reserves the right to modify this guideline as necessary with engineering judgment.

* Tapping allowed on buses: 250 kV and below, 250 kV and below, 250 kV and below, 250 kV and below, 250 kV and below.

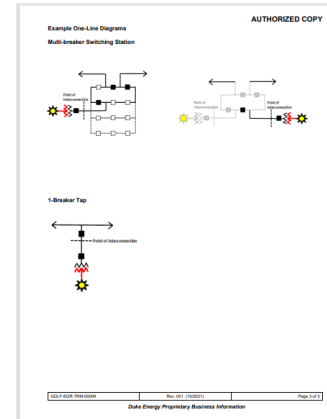
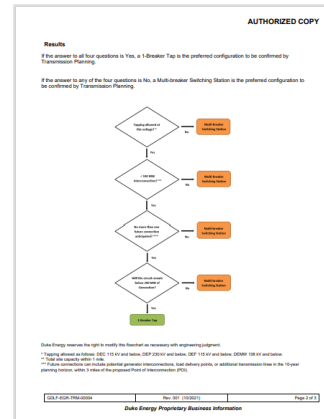
** Total site capacity is the total capacity of all interconnections, not additional points, or additional interconnection lines in the 15-year planning horizon, within 1 mile of the proposed Point of Interconnection (POI).

*** Additional future connection is defined as a connection to a new transmission line or a new interconnection to an existing transmission line.

**** IBR generation on the circuit remain below 250 MW.

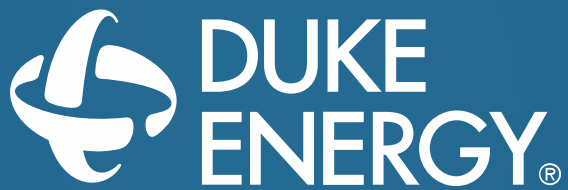
GDUF-0228-1988-00004 Rev. 01 11/2021 Page 1 of 1

Duke Energy Proprietary Business Information



- Contact TSRG representatives with any questions.

ATTACHMENT G



TSRG Meeting

October 20, 2021

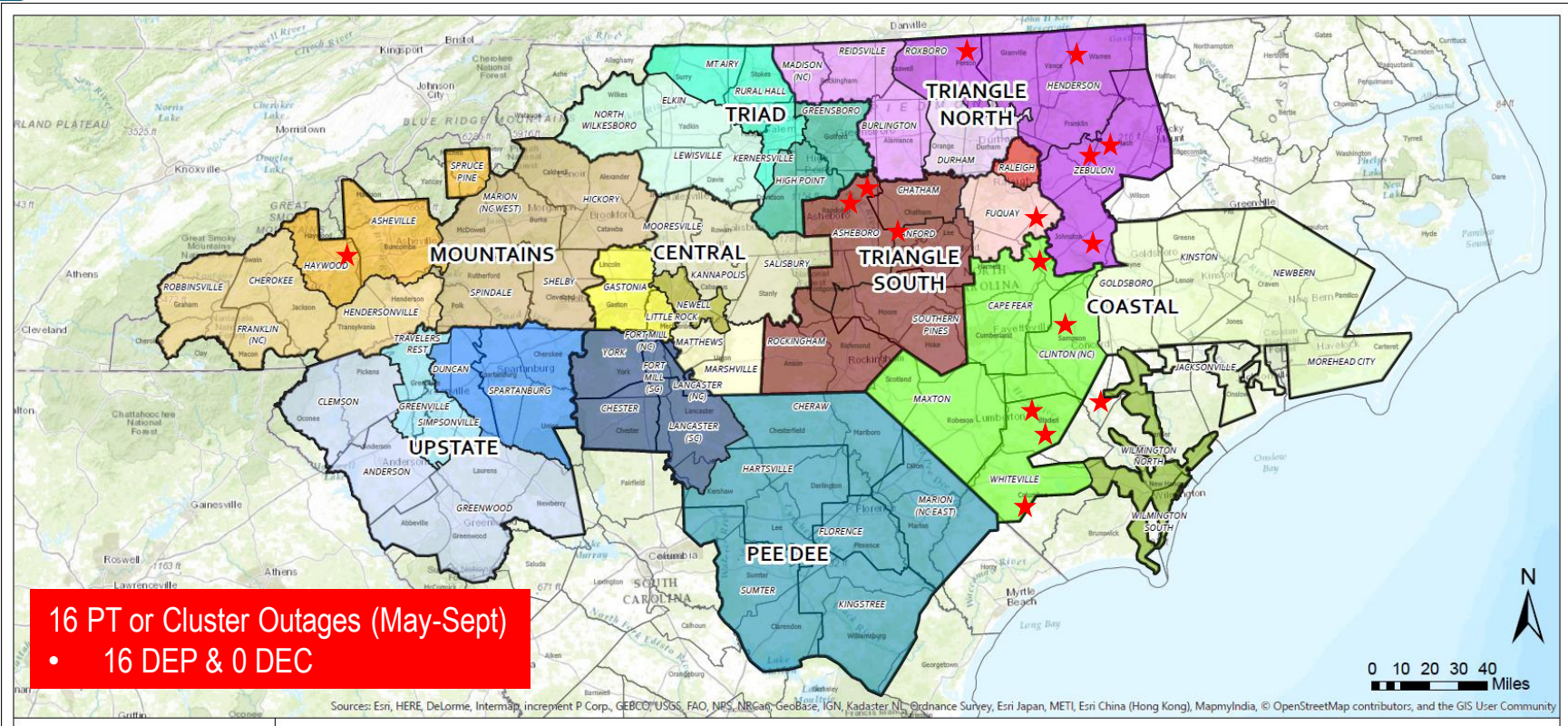
Operations Update



- Outage Update - Meter Pole PT & PT Clusters (May – Sept 2021)
- PT Cluster Build Process - High Level Handoffs and Drivers
- Update - Bypassing the Metering PT

Meter Pole PT and PT Cluster Outages by Location

ATTACHMENT H



Meter Pole PT and PT Cluster Outages (May – Sept 2021) ATTACHMENT H

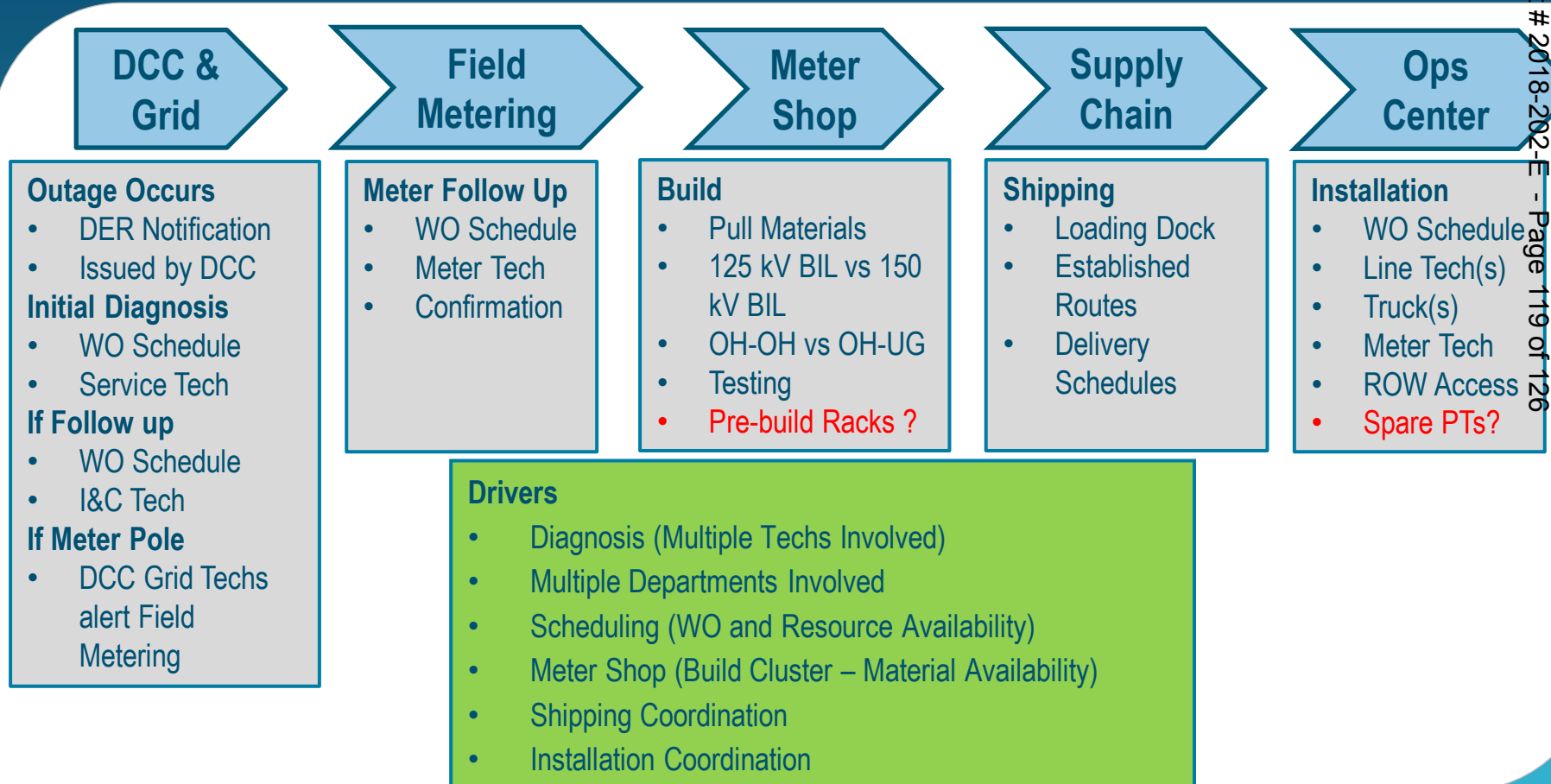
County	Recloser	Outage Start	Outage End	Days	PT or Cluster
Chatham	1BLN98	05/28/21	06/09/21	12	PT
Wake	188M91	06/13/21	06/25/21	12	Cluster
Bladen	1B0F17	06/13/21	06/24/21	11	PT
Johnston	1ARW75	07/03/21	07/23/21	20	Cluster
Duplin	1AQT34	07/08/21	07/28/21	20	Cluster
Warren	18TM95	07/15/21	07/29/21	14	PT
Bladen	1D2M38	07/26/21	08/03/21	8	PT
Randolph	1CJH35	08/07/21	08/12/21	5	PT
Columbus	17RK78	08/12/21	08/13/21	1	PT
Person	1CWP36	08/12/21	08/24/21	12	Cluster
Nash	1BKB16	08/16/21	08/23/21	7	Cluster
Randolph	1BXQ31	08/20/21	08/24/21	4	PT
Haywood	1B1X37	08/23/21	09/07/21	15	Cluster
Duplin	1BNW03	08/25/21	09/09/21	15	Cluster
Nash	1B1B60	08/28/21	09/08/21	11	Cluster
Cumberland	1AWG43	09/21/21	09/28/21	7	Cluster

Restoration Time

- Overall Average 10.87 Days
- 7 PTs
- Avg 7.86 Days, Range 1 - 14 Days
- 9 Clusters
- Avg 13.22 Days, Range 7 - 20 Days

Good News - Trending In Positive Direction

Meter Pole PT and PT Replacement Process and Drivers ATTACHMENT H



Bypassing The Metering PT

ATTACHMENT H

- Collaborative solution made by Carolinas leadership: Customer Delivery, Grid Management, Metering, Major Projects, and DET to bypass the meter or replace the PT/PT Cluster within 72 hours.
- Metering to use the data from 2/3 of KWH metering still in service to estimate the third phase.
- Backup option to use KWH value on site recloser if meter off due to failed PT.
- Service Tech to work with Meter Tech to perform bypass procedure and clear the PT without needing a crew on site until the PT/PT Cluster is replaced.
- **Next Step** - Roles & Responsibilities document to be developed to show process and handoffs between DCC, Metering, Ops Center, and Complex Billing.

Questions ?

ATTACHMENT H

General Discussion and Updates

Technical Standards Review Group (TSRG) Meeting
October 20, 2021

Enterprise Protection Update

Philip Baker, Duke

POI Recloser optimization research:

- Reclosers on Area EPS (Utility Distribution Feeder) typically at sites $\geq 1\text{MW}$
- Consultant research project is making forward progress. Results projected Q1 2022
- Optimize protection scheme with a balanced approach considering:
 - Ride-Through
 - Local Area EPS fault detection
 - Unintentional Islanding detection
 - Coordination with DER Protection Settings (Plant level and inverter settings)
- Evaluate optimized performance
- Consider Risk-Based options based on experiential data and quantifiable metrics
- Stakeholder engagement

Enterprise Protection Update, continued

POI Recloser Protection Settings: (New standard settings)

- In-Service Sites (Changes projected start mid-2022 and continue through 2023)
- New Sites (Projected to start mid-2022)

DER Protection Settings: (New standard settings at plant level and inverters)

- Stakeholder engagement
- In-Service Sites (Changes projected start mid-2022 and continue through 2023)
 - Sites that have a POI Recloser
 - Review capability at plant level and inverters
 - Change Settings
- New Sites (Projected to start mid-2022)

General Discussion and Updates

- Enterprise Substation Configuration – Kristina Straple, Duke
- Standalone storage discussion
 - Introduction of topic – Mike Wallace, BrightNight
 - Discussion facilitator – Ken Jennings, Duke
- Guidance map update
 - DG Guidance map publication postponed from October 2021 to January 2022.
 - Projects currently in the interconnection queue have a 10/31 deadline to make a decision on whether they will withdraw or participate in the first (transitional) cluster study. As a result, substantial changes to the queue are expected in early November and would make an October update immediately obsolete.

